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SOLAR INSOLATION RECORDING SYSTEM (SIRS) REFERENCE MANUAL.(U)
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SOLAR INSOLATION RECORDING SYSTEM (SIRS) REFERENCE MANUAL

SMSGT EDWARD E. STAPLETON
1st LT MICHAEL R. MANTZ

DECEMBER 1979

INTERIM REPORT
JANUARY 1977 - DECEMBER 1978

APPROVED FOR PUBLIC RELEASE;
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ENGINEERING AND SERVICES LABORATORY
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TYNDALL AIR FORCE BASE, FLORIDA 32403

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Solar Radiation
Solar Insolation
Solar Insolation Recording System
Data Acquisition System
Data Recorder
Data Logger
Digital Data Collection System

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This manual provides the installation procedures, theory of operation, and maintenance procedures necessary to install, operate, calibrate, maintain and understand the Solar Insolation Recording System (SIRS) which is a microcomputer-based data acquisition system used to collect solar insolation data. Traditionally solar data has been collected in an analog format (strip chart). Large quantities of data were particularly difficult to manipulate. Therefore, to simplify the processing of data, a data acquisition system was designed and built which produced a computer compatible data medium.

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cont.

In the case of SIRS, the data media is digital cassette tapes. These tapes can be read into a larger computer where complex data manipulation/processing can be accomplished. This document strictly addresses the data acquisition system. Data reduction and manipulation will be covered in the final technical report on Solar Radiation Measuring.

PREFACE

This report was prepared by SMSgt Edward E. Stapleton and 1st Lieutenant Michael R. Mantz of the Energy Research Office, Engineering and Services Laboratory, Air Force Engineering and Services Center. The development was conducted by SMSgt Stapleton and 1st Lt Mantz as part of a larger Solar Radiation Measuring effort.

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This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This report has been reviewed and approved for publication.

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Services Laboratory

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SECTION I

INTRODUCTION

1.0 BACKGROUND

This interim technical report addresses the Solar Insolation Recording System (SIRS), a piece of hardware developed as a part of a larger effort on Solar Radiation Measuring. This project was undertaken to provide (1) an adequate data base for large scale design of solar energy collectors, (2) to provide correlation between local measurements of solar radiation and regional measurements being taken by National Oceanic and Atmospheric Administration (NOAA) and (3) to determine the applicability of this equipment to current or future Air Weather Services procedures. The hardware/software development began in January 1978 and was completed in April 1978.

The system was initially tested from June 1978 to August 1978. It was installed at Det 9, 12th Weather Squadron, 3rd Weather Wing, Tyndall AFB, Florida on 11 November 1978 for operational testing. Development was initiated by the Air Force Civil Engineering Center and was completed by the Civil and Environmental Engineering Development Office (CEEDO). Since this effort was completed, CEEDO has become the Directorate of Research and Development of the Air Force Engineering and Services Center (AFESC).

2.0 PURPOSE OF MANUAL

This manual provides the user with the installation procedures, theory of operation, and maintenance procedures necessary to install, operate, calibrate, maintain and understand the SIRS, developed and constructed by members of the Energy Research Office of the Air Force Engineering and Services Laboratory (Figure 1). Schematics of SIRS components are presented in Appendix A.

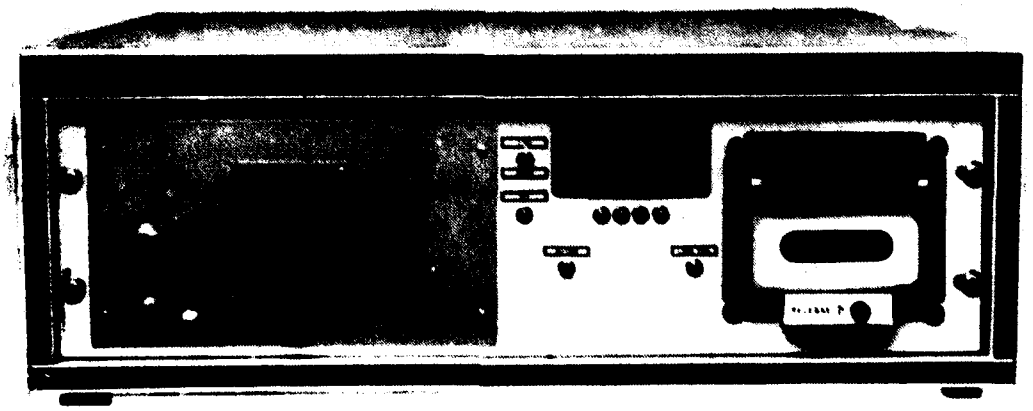


Figure 1. Solar Insolation Recording System
(Less Pyranometer)

SECTION II

INSTALLATION[1]

The site for an upward-looking pyranometer should be free from any significant obstructions above the plane of the sensing element and, at the same time, should be readily accessible. If practicable, the instrument should be so located that (a) a shadow will not be cast on it at any time (e.g. by radio masts, etc.); (b) it is not close to light-colored walls or other objects likely to reflect sunlight onto it; and (c) it is not exposed to artificial radiation sources.

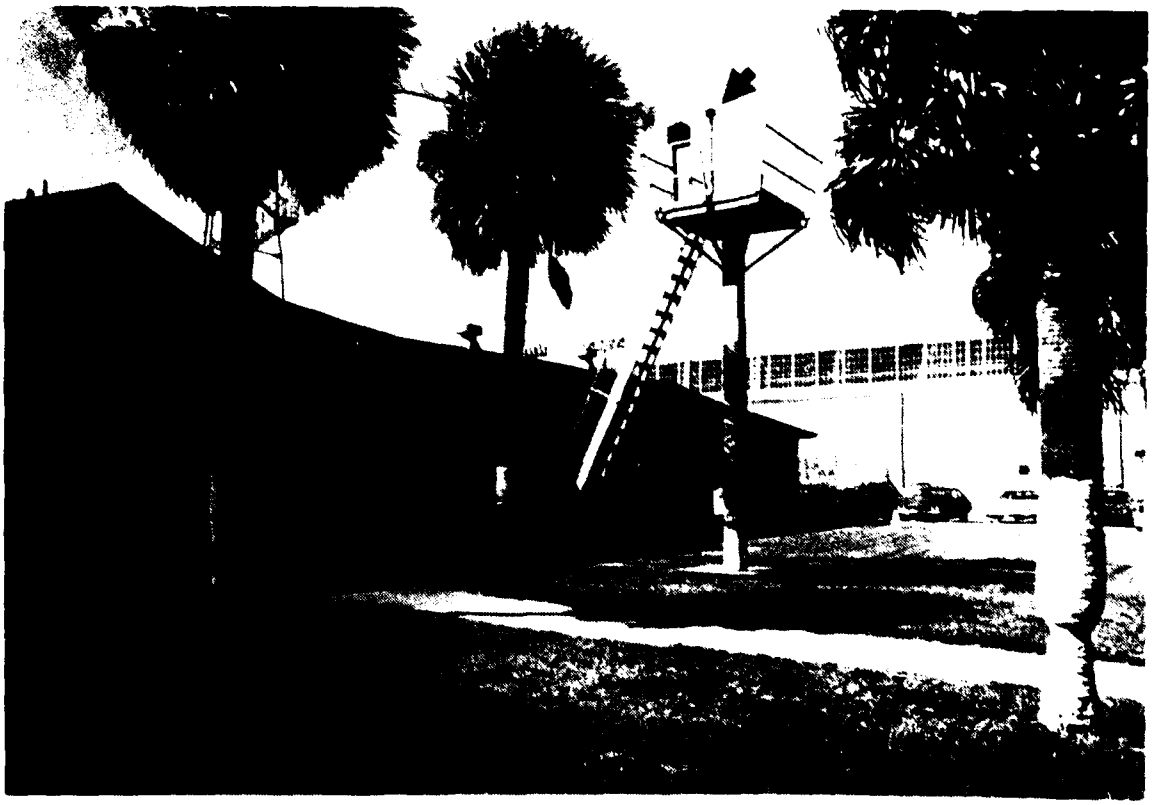


Figure 2. Weather Station Pyranometer Installation

[1] Reference "Eppley Electronic Integrator Instructions, Models 410," Eppley Laboratory, Inc.

At most places, a flat roof provides the best location for mounting the instrument; if such a site cannot be obtained, a rigid stand with a horizontal upper surface some distance from structures or other obstructions should be used.

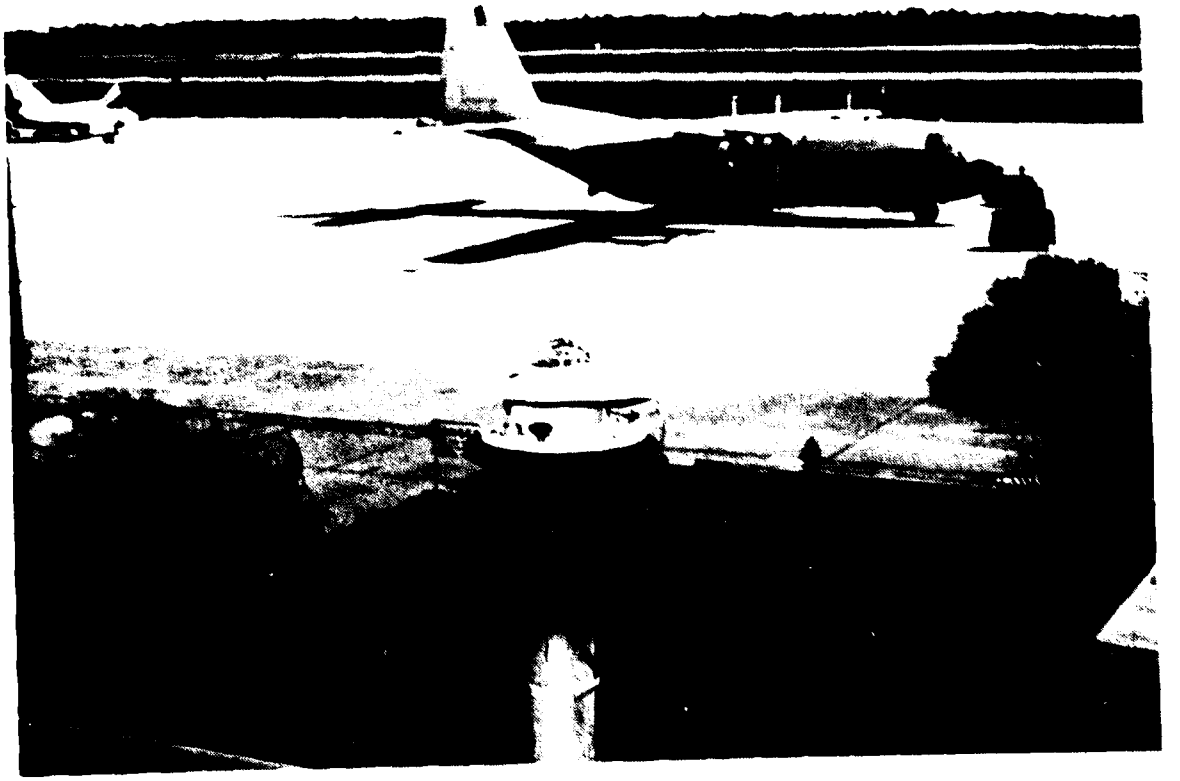


Figure 3. Eppley Precision Spectral Pyranometer (Installed)

The pyranometer should be connected to the recorder by a cable of no more than 50 feet in length to prevent generating common-mode voltages.

The integrator recorder requires only a source of 115 VAC, 60 Hz.

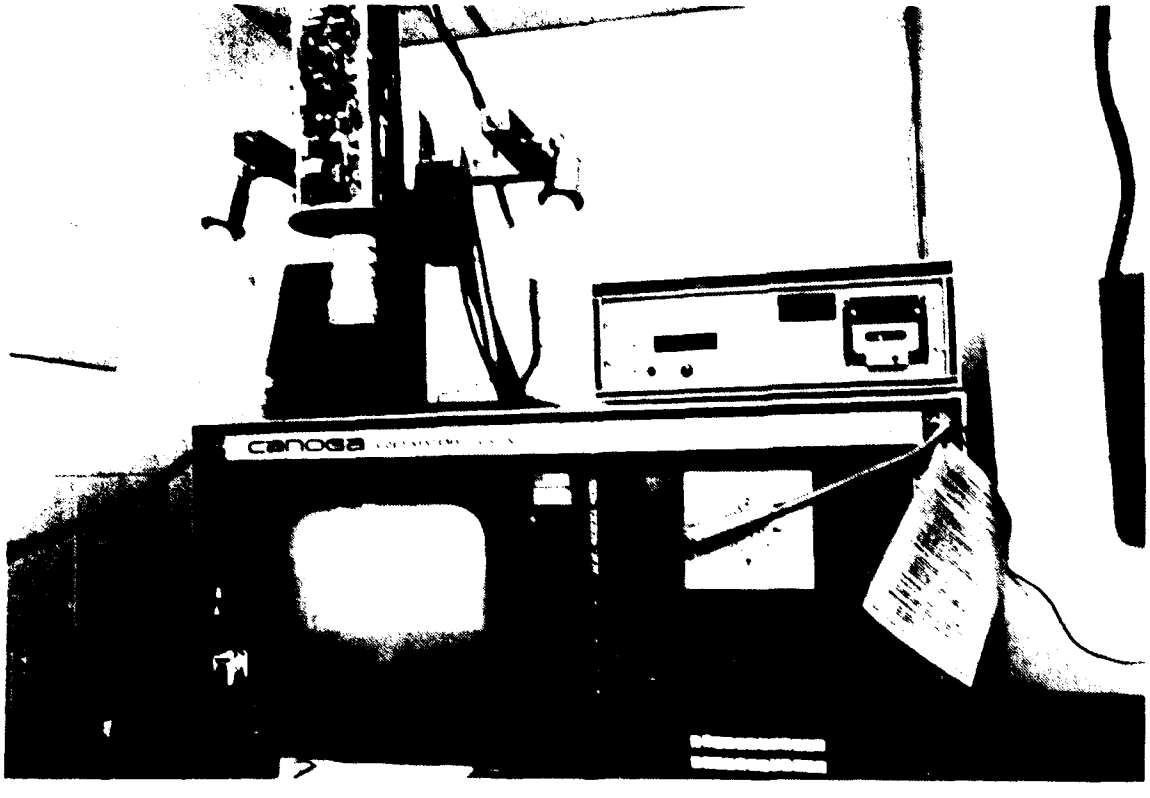


Figure 4. SIRS Recording System Installed

SECTION III

OPERATION

A self-explanatory checklist is provided in Table 1 for operation of the recording system.

It should be noted that the clock must be reset if even a momentary power failure occurs (due to lightning strikes, etc.) since no provision was made for battery backup of the random access memory.

Tapes used may be Datel® certified digital cassettes, part number 12123-1 or equivalent. Ten to eleven months of data (at 60-minute intervals) can be recorded on one cassette.

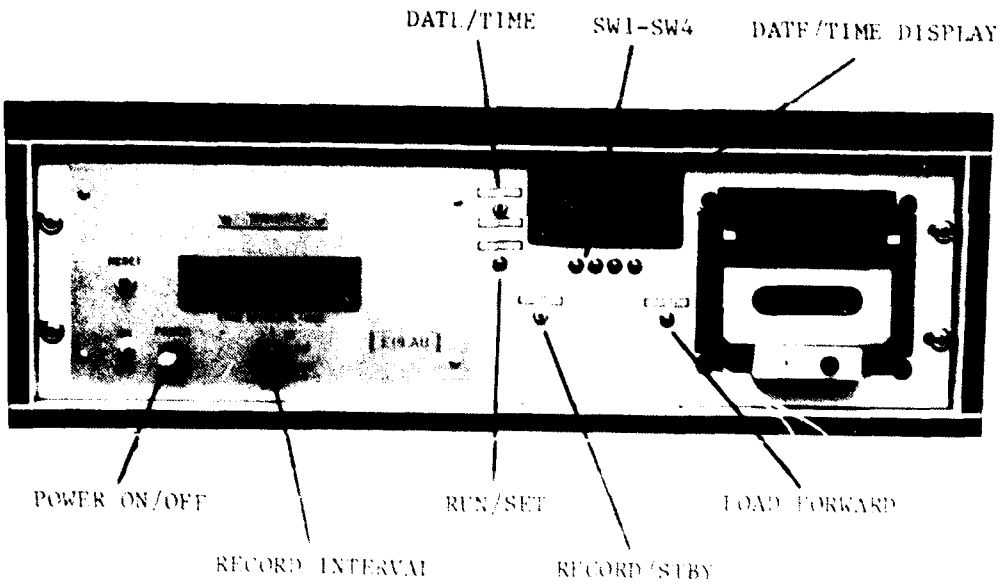


Figure 5. SIRS Front Panel

TABLE 1. OPERATION OF SOLAR INSOLATION RECORDING SYSTEM

A. Start Up:

1. Turn on power.
2. Set record interval (1, 10, or 60 minutes).
3. Set "record" switch down.
4. Set "date/time" switch to time.
5. Set time:
   Depress "set" switch while incrementing display using switches under individual digits (24-hour time).
6. Set date/time switch to date.
7. Set Julian date as in step 5 above.
   (8235 = 1978 235th day)
8. Install cassette.
9. Depress load forward until leader is run off.
10. Depress bar on top of recorder so head contacts tape.
11. Set "record" switch up.

B. Changing Tapes:

1. Set record switch down.
2. Depress release button on recorder.
3. Remove tape.
4. Install new tape.
5. Depress load forward until leader is run off.
6. Depress bar on top of recorder so head contacts tape.
7. Set record switch up.

C. Power Failure/Reset:
Set time and date as in A5, A6, and A7.

SECTION IV

CALIBRATION

The end instrument should be calibrated once a year or prior to being installed if more than a year has elapsed since the last calibration.

The pyranometer (not the recorder) should be sent to:

Solar Radiation Facility
National Oceanic and Atmospheric Adm
Environmental Research Laboratories
Boulder CO 80302
ATTN: Mr Edwin C. Flowers

Calibration takes approximately three weeks.

The integrator can be calibrated using a 10-millivolt source to adjust the gain and offset.

With a NOAA calibration of 8.83×10^{-6} volts/watt-meter^{-2}, the counter is adjusted to produce 359.2 counts/hour with a 10 mV input using the formula:

$$\text{Sensitivity} = \frac{8.83 \times 10^{-6} \text{ V}}{\text{W/m}^2} \times \frac{3.152 \text{ W/m}^2}{\text{Btu/ft}^2 \text{ - hour}}$$

$$= 35.92 \text{ Btu/ft}^2\text{-hour/mV}$$

$$10 \text{ mV} = 359.2 \text{ Btu/ft}^2\text{/hour}$$

where the derived constant is 8.83×10^{-6} V/W/m^2 and

1 Btu/ft^2-hour = 3.152481 W/m^2

SECTION V

MAINTENANCE

Pyranometers in continuous operation should be inspected, ideally, at least once per day. At these inspections, the (outer) hemisphere should be wiped clean and dry with a lint-free soft cloth. In desert or arid regions, the hemisphere should be cleaned very gently in order to prevent scratching of the surface. Such abrasive action can alter appreciably the original transmission properties of the material and, hence, the radiometer calibration. If frozen snow, glazed ice, hoar frost or rime is present, an attempt should be made to remove, at least temporarily, the deposit carefully with warmed cloths. In the polar regions, it will be necessary to experiment to discover the best method of keeping pyranometers frost free. It has been found that warm cloths (heated inside the recorder hut and held against the body while travelling between hut and instruments) are sometimes useful. Under some conditions, it is impossible to keep frost off the instruments for any length of time; in such instances, attempts should be made to remove frost at convenient times during the day when the sun is shining.

Should the internal surface of the (outer) hemisphere become coated with moisture, it can be cleaned by careful removal on a dry day, allowing the air to evaporate the moisture and then firmly resecuring the hemisphere. The inside of the hemisphere should not be wiped unless smears are visible. Precautions should be taken to avoid scratching the undersurface of the collar carrying this hemisphere. The external surface of the inner hemisphere can also be cleaned, if necessary, when the outer one is removed. Should moisture be deposited on the inside of the small hemisphere, it can similarly be removed. However, extreme care must be exercised since the thermopile element is now unprotected and could be seriously damaged.

Occasionally, the desiccator installed in the pyranometer case should be inspected. Whenever the silica gel drying agent is pinkish or white in color, it should be replaced. (Silica gel can be rejuvenated by drying in an oven at about 135°C for a few hours, until the original dark blue color reappears).

The circular spirit level of the pyranometer should be inspected at regular intervals.

Other than verification of proper operation, no preventive maintenance is required for the recording equipment.

SECTION VI

SYSTEM OVERVIEW

The instrumentation system consists of a pyranometer, an integrator, a single-board microcomputer, a digital cassette recorder, and a front panel which consists of a four-digit display and input switches (Figure 6).

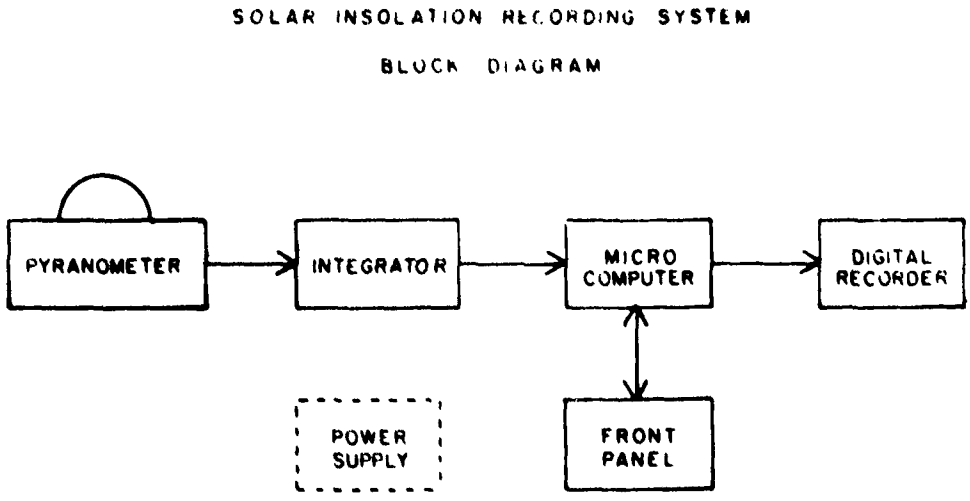


Figure 6. SIRS Block Diagram

1.0 HARDWARE OVERVIEW

The pyranometer is an Eppley Laboratory Precision Spectral Pyranometer, Model PSP. The output of the pyranometer thermopile is fed directly to the input of an Eppley Laboratory Electronic Integrator, Model 411, where the low level analog signal from the pyranometer is amplified and converted into a pulse-rate output proportional to the input signal. This output pulse train is counted and totalized to produce the integral of the input signal. The count is displayed on an electronic digital counter which counts in binary coded decimal (BCD). The BCD from the display is also paralleled to connector P102 at the rear of the integrator, along with the interval selection switch and integrator reset.

The microcomputer is an Intel Single Board Computer, SBC 80/10, with an Intel SBC 630 power supply. The SBC has an 8080 CPU, system clock, 1K by 8 bit words of read/write memory (RAM), provision for up to 4K by 8

bits of read-only-memory (ROM), 48 parallel input output (I/O) lines (two groups of three ports, eight lines per port) and a serial communications interface (Figure 7).

The recorder is a Datel DI2-lo cassette data logger, modified by removing its analog to digital converter and multiplexer cards. It receives and serially records an eight bit parallel output from one of the 8BC ports. An interface card converts the 5-volt 8BC output to a 12-volt level for the recorder, (TTL/CMOS) (Figure 7).

The display consists of four Hewlett Packard 5082-7340 solid state hexidecimal indicators. They have self-contained decoder drivers and latched memory. A positive logic 1 2-4-8 is decoded into 16 states, 0-9 and A-F, for display. It is used to display the Julian date and time.

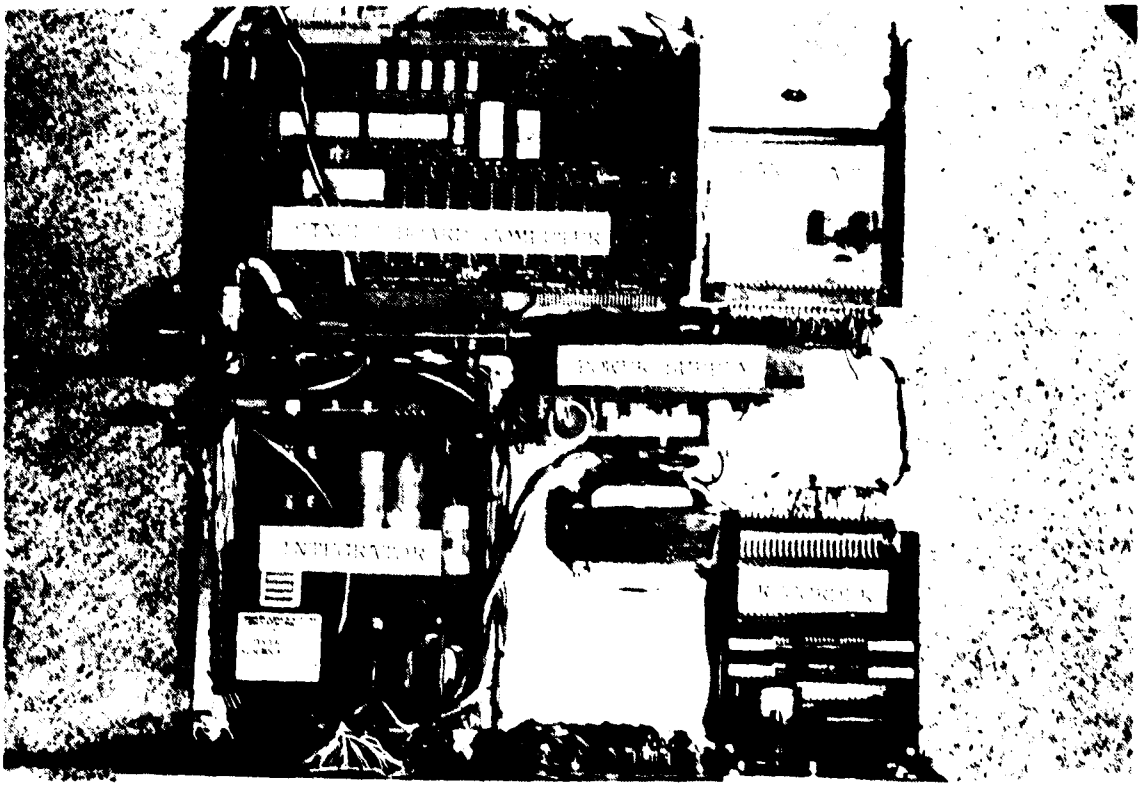


Figure 7. RTS subsystem layout

The real time interrupt driven clock is a software clock that is incremented by a hardware interrupt synchronized to the 60 cycle line frequency (Figure 8). Switches are provided to set and display the date time, disable recording during loading of a tape, and load forward new tape off the leader.

Power for everything except the interface is supplied by the CBC 610 power supply.

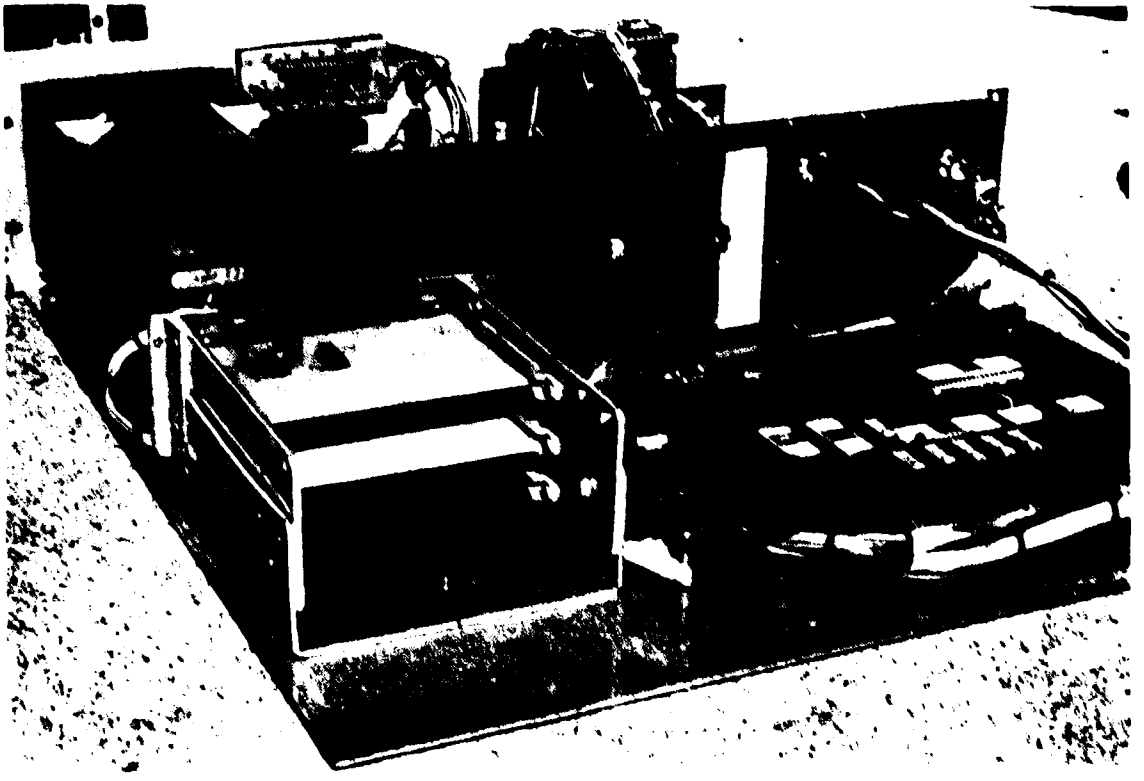


Figure 8. Card Cage

2.0 SOFTWARE OVERVIEW

After power-up, the program initializes the I/O and selected memory locations and then enters the main loop. The main loop simply calls three subroutines, checks the position of the date/time switch, displays either the date or time, and then jumps to the beginning of the main loop.

The first routine, called STBYCK, senses the record/standby switch position and sends a file gap to the recorder on a transition from "stand-by" to "run." This in turn resets the recorder word counter.

The next routine, RCDTM, checks the time and at seconds = ØØ stores the integrator output, resets the integrator, and then records the date, time, data, and interval.

SWCHK scans the front panel switches. If a switch is depressed, SWCHK increments the appropriate counter. If no switch is depressed, the routine is exited.

TIMIT is an interrupt-driven, real-time software clock. An interrupt is generated every sixtieth of a second by a hardware, real-time clock generator. These interrupts temporarily stop the execution of the main program loop. TIMIT updates the time and date counter and then returns control to the main programs.

SECTION VII

THEORY OF OPERATION

1.0 SYSTEM INITIALIZATION

System power is applied through the "on-off" switch on the integrator. This causes a power-on reset sequence in the microprocessor, which immediately jumps to PROM memory location 50H where initialization is started. To initialize the I/O ports, (see Appendix B), an initialization word is sent to the appropriate control registers. Group B I/O ports automatically come up with all ports set for "INPUT." Group A I/O ports are set so port 1 is "INPUT" and ports 2 and 3 are "OUTPUT." Memory locations for time, date, and interval are initialized to ØØ (See Appendix C.)

An integrator reset and a recorder file gap command are also generated at this time. This is accomplished by strobing bits 5 and 6 of port 2 low, then high. All output ports are active low. The integrator requires an active low for reset; however, the recorder requires active high for all inputs, control and data. The recorder also requires a +12 volt logic level. Since the port output is only +5 volts, an inverting buffer is used to drive all recorder inputs; the output of the buffer is active high at +12 volts.

2.0 RECORD/STANDBY SWITCH

After initialization, the first subroutine called STBYCK checks the setting of the record/standby switch, SW7, (all front panel switches are debounced prior to being applied to a port). The output of the debouncer for SW7 (J102-S) is applied to port 1 bit 6 (J1A-18), where it is checked for 'record' or 'stby.' If 'stby,' a flag is set and the subroutine is exited. The first time this subroutine is called after SW7 is put into the "record" mode, a check is made of the flag. If set, a file gap is generated and the flag reset, which insures only one file gap will be generated for each transition of the switch from standby to record. This allows tapes to be changed and the recorder word counter to be reset without interfering in any way with the other operations. When SW7 is in the standby position it also holds off the recording process in the subroutine RECDAT.

3.0 TIME/DATE SET SWITCHES

SW5 (run/set) is a momentary-on switch that must be held down while incrementing the date or time. It appears at port 1 bit Ø (J1A-21), and is sensed in SWCHK. After the program determines that SW5 is in the "set" position it checks SW6, port 1 bit 1 (J1A-22) for date or time (date = active high, time = low). If SW6 is in the date position, first the date will be displayed and then the four switches (SW 1 through SW 4) will be scanned. The memory location for the digit above a switch will be incremented each time that a switch is depressed and the new number is displayed.

The diagram below depicts the relationship of SW1 through SW4 to the display, input port, and SBC connector J1A.

Switch	Display Digit	Port 1	SBC Input
1	1	Bit 2	J1A 23
2	2	Bit 3	J1A 24
3	3	Bit 4	J1A 20
4	4	Bit 5	J1A 19

If SW6 is in the time position the memory locations for time will be incremented in the same manner as the date, above.

4.0 TIME/DATE DISPLAY

The data inputs of the individual digits of the display are wired in parallel. After data are latched up at the output of port 3, the individual display digit selected for displaying that data is strobed and the data latched into the digits memory where they are retained. The lower four bits of port 3 are used for both the display and the eight bit word sent to the recorder. The "digit latch" and "record" strobes determine which of these responds to, or accepts, the data for input. Port 2 bits Ø through 3 (J1A-4 through J1A-1) make up the display digit latch (strobe) port; outputs are normally held high and strobed low when loading the display.

5.0 DIGITAL CASSETTE RECORDER INTERFACE

The data output from the integrator (P102 pins 1-20) are an active high, six digit, BCD number in the format 1-2-4-8, 10-20-40-80, etc. J102 connects directly to J2A, (group B, ports 4, 5, and 6). Of the four upper bits of port 6 that remained, bits 4, 5, and 6 are used to sense the position of the interval switch on the integrator. P102 pin 22 is grounded when an interval rate of 1-minute is selected (active low) and is routed to J2A, pin 14 (bit 4, port 6). When "seconds = ØØ" (once each minute), the internal switch is scanned; and if interval equals 1 minute, the data from the integrator are sensed and stored in memory. The integrator then is reset and counting is begun on the next cycle while the date, time data, and interval are recorded.

The recording process consists of accessing the memory location containing the required data, i.e., date, and outputing it to the recorder with a strobe to start recording. The recorder immediately returns a "recorder busy" and holds it high until the data have been converted from parallel to serial and have been put on tape. This "busy bit" is monitored until it returns low, at which time new data are sent to the recorder. This continues until all the data are recorded, after which the program returns to the main loop until the next record time.

Data to the recorder are latched up at J1A 9-16 (port 3 bits Ø through 7). From there it is converted to a 12-volt level before being applied to the recorder input. J1A-6 (port 2, bit 5) is the output for the record strobe, and it, also, is amplified prior to being sent to the recorder.

The "busy-bit" appears at recorder I/O plug, P1A-F, and is changed from active 12 VDC to active 5 VDC before being applied to J1A-17 (port 1 bit 7).

6.0 REAL TIME CLOCK

The main program is interrupted every sixtieth of a second by the output of the interrupt generator, which causes all processing of the main loop to be temporarily suspended while the real time clock is incremented by software in the subroutine TIMIT.

The interrupt generator uses the 5 VAC from the power supply to lock the timing to the line frequency. The 60-Hertz input is clipped and applied to a 7413 Schmitt trigger for shaping before driving a 74121 monostable multivibrator. The "not Q" output is used to drive the SBC interrupt input to the processor (J1A-25). The pulse width of the one shot was selected to be greater than the longest instruction execution time of the processor and less than the time it takes to reach the interrupt enable instruction within TIMIT. This was to prevent the processor from being interrupted more than once by the same pulse.

7.0 FLOWCHART AND SOURCE SORTWARE

Pertinent flowcharts and source software are presented in Appendices D and E, respectively.

BIBLIOGRAPHY

1. SBC 80/10 Single Board Computer Hardware Reference Manual, Intel Corporation, 1976.

2. SBC 630 Power Supply User's Manual, Intel Corporation, 1976.

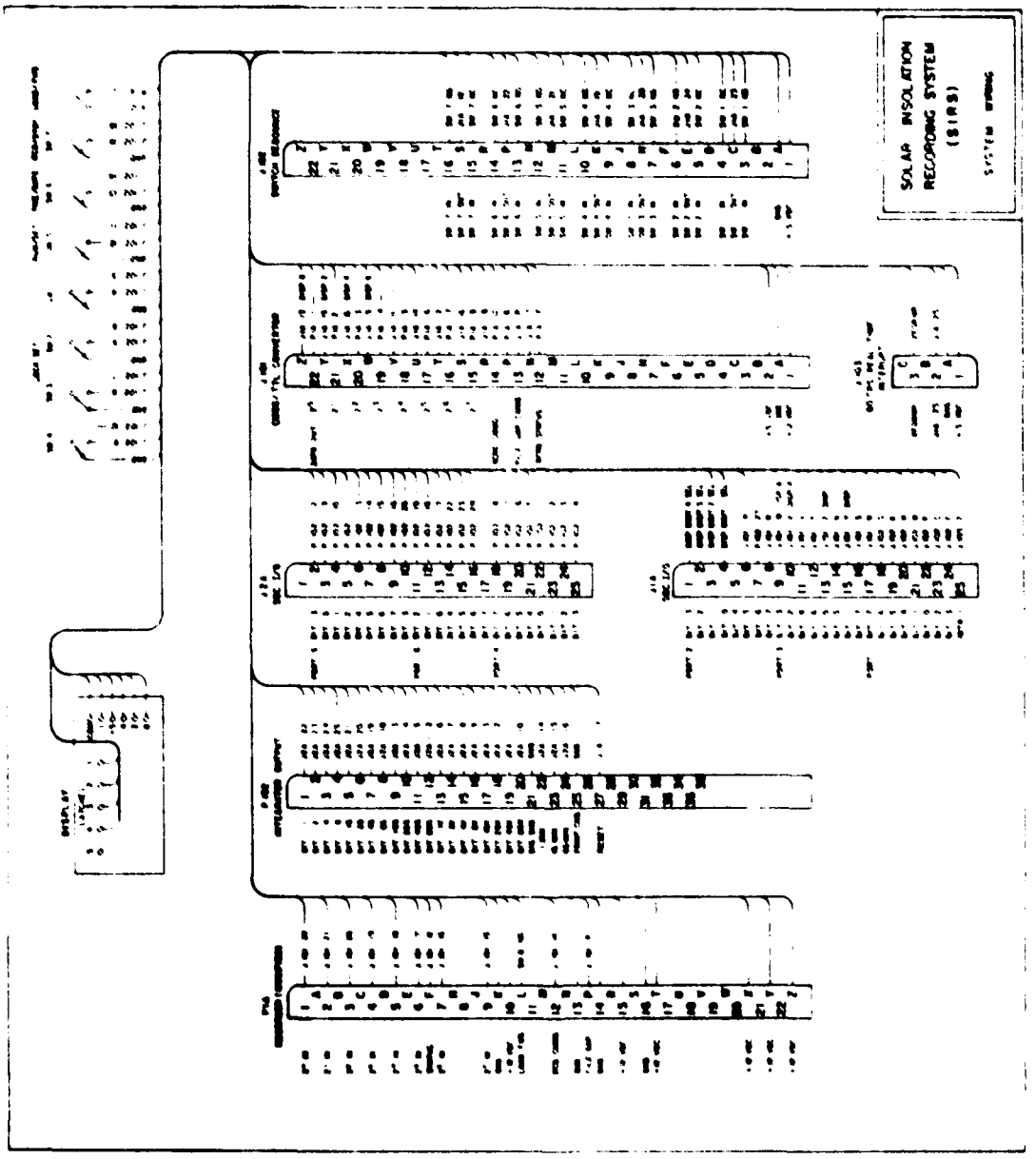
3. LPS-16 Cassette Data Logger Instruction Manual, Datel Systems, Inc., 1975.

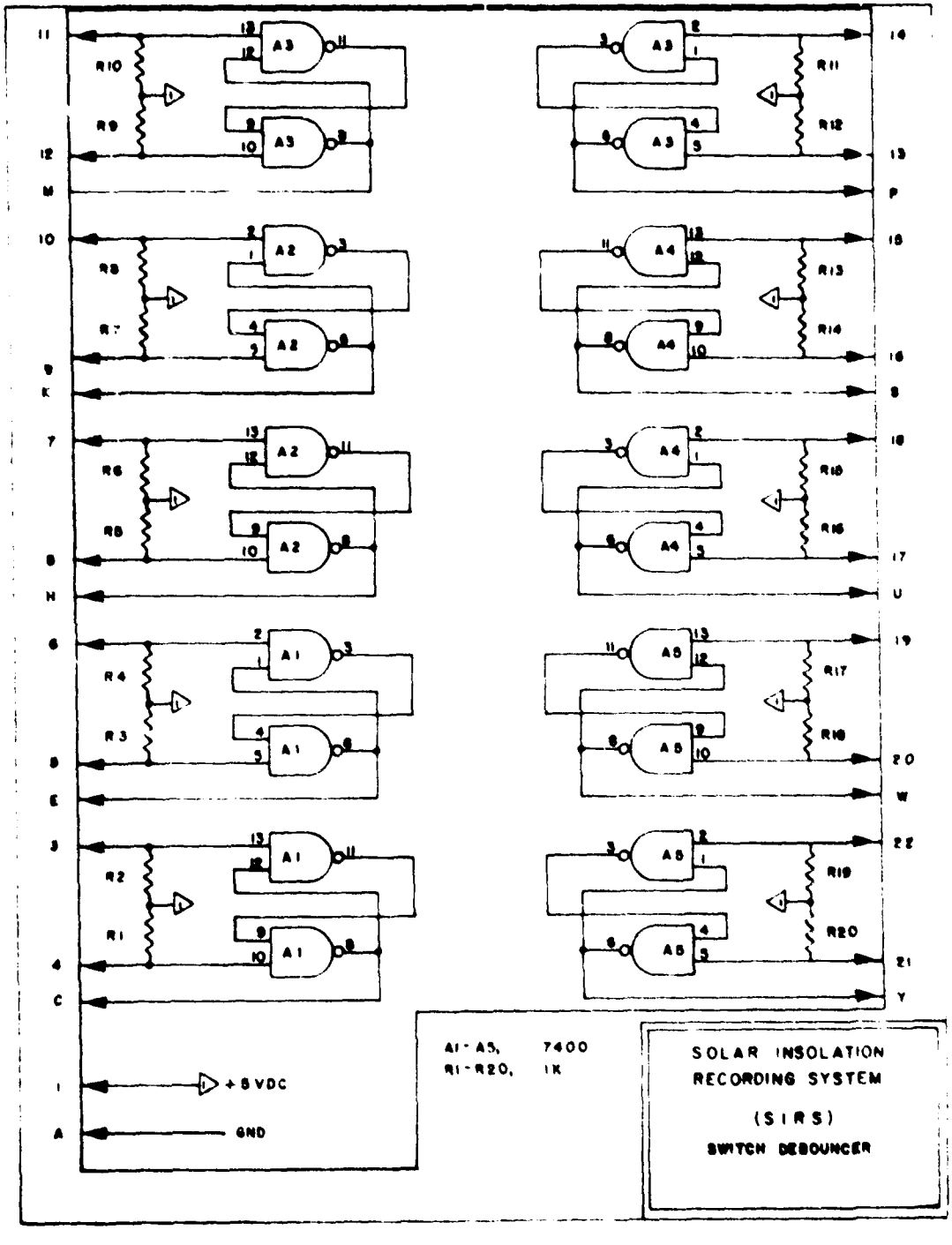
4. "Eppley Electronic Integrator Instructions, Models 410," Eppley Laboratory, Inc.

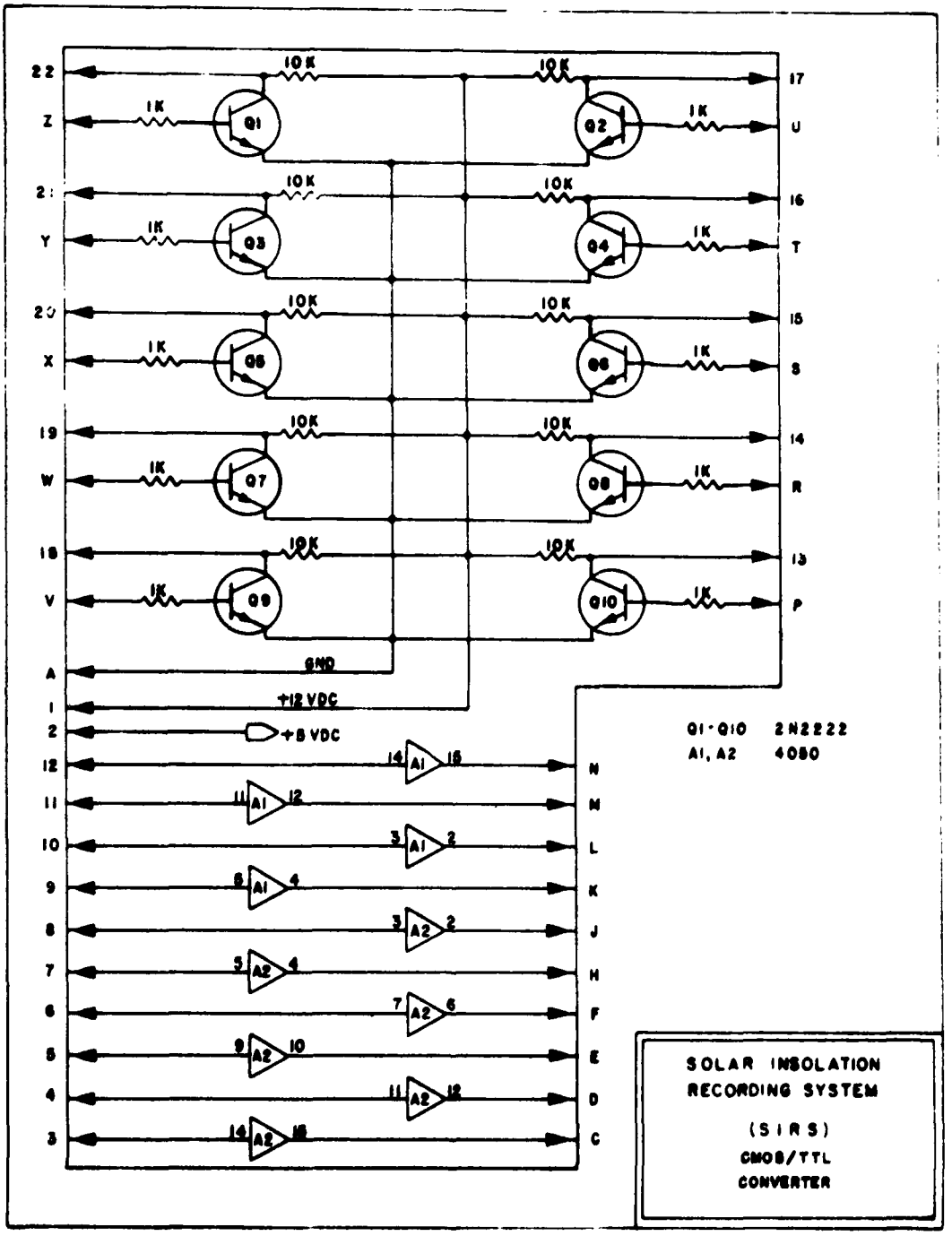
5. "Instrumentation for the Measurement of the Components of Solar and Terrestrial Radiation," Eppley Laboratory, Inc.

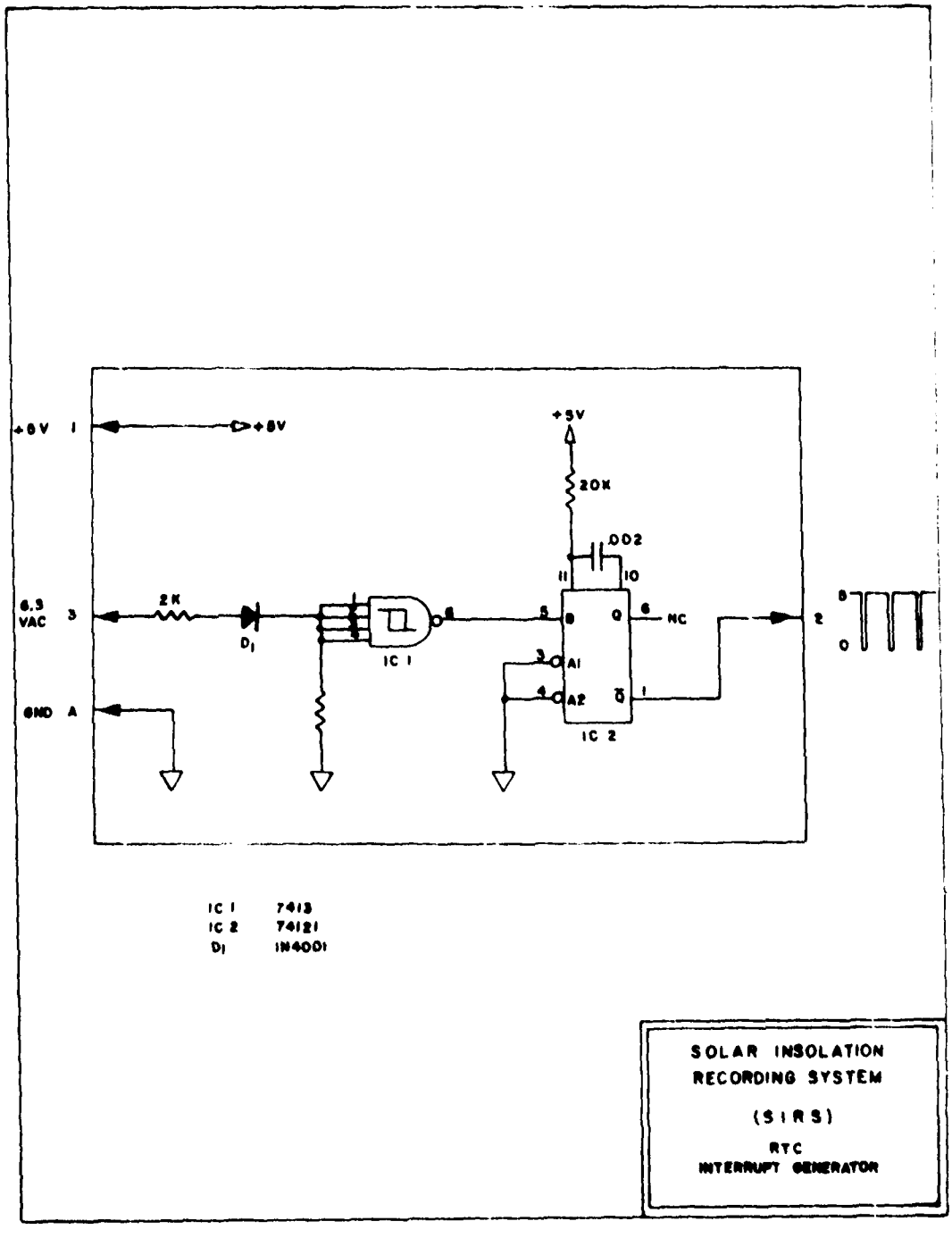
APPENDIX A

SCHEMATICS OF SIRS COMPONENTS




A1 - A5, 7400
R1 - R20, 1K
+5 VDC
GND
SOLAR INSOLATION
RECORDING SYSTEM
(SIRS)
SWITCH DEBOUNCER


22
Z
10K
1K
Q1
Q2
17
U
21
Y
Q3
Q4
16
T
20
X
Q5
Q6
15
S
19
W
Q7
Q8
14
R
18
V
Q9
Q10
13
P
A
GND
1
+12 VDC
2
+5 VDC
12
11
10
9
8
7
6
5
4
3
A1
A2
N
M
L
K
J
H
F
E
D
C
Q1-Q10 2N2222
A1, A2 4050
SOLAR INSOLATION
RECORDING SYSTEM
(SIRS)
CMOS/TTL
CONVERTER



IC 1 7413
IC 2 74121
D1 IN4001

APPENDIX B

I/O SUMMARY

PORT NAME	ADDRESS	BIT		I/O FUNCTION
Port 1	ØE4H	Ø	-	Time/Date Switch
Group 1, Port A Mode Ø Input		1	-	Run/Set Switch
		2	-	MS Digit Switch
		3	-	2nd MS Digit Switch
		4	-	2nd LS Digit Switch
		5	-	LS Digit Switch
		6	-	Record/Standby Switch
		7	-	Recorder Status Bit (Busy Bit)
Port 2	ØE5H	Ø	-	MS Digit Latch
Group 1, Port B Mode Ø Output		1	-	2nd MS Digit Latch
		2	-	2nd LS Digit Latch
		3	-	LS Digit Latch
		4	-	Not Used
		5	-	File Gap Command
		6	-	Integrator Reset
		7	-	Record Command
Port 3	ØE6H	0	-	Digit Data Ø/Recorder Data Ø
Group 1, Port C Mode Ø Output		1	-	Digit Data 1/Recorder Data 1
		2	-	Digit Data 2/Recorder Data 2
		3	-	Digit Data 3/Recorder Data 3
		4	-	Recorder Data 4
		5	-	Recorder Data 5
		6	-	Recorder Data 6
		7	-	Recorder Data 7
Port 4	ØE8H	Ø	-	Integrator Bit 1
Group 2, Port A Mode Ø Output		1	-	Integrator Bit 2
		2	-	Integrator Bit 4
		3	-	Integrator Bit 8
		4	-	Integrator Bit 10
		5	-	Integrator Bit 20
		6	-	Integrator Bit 40
		7	-	Integrator Bit 80

APPENDIX B continued

PORT NAME	ADDRESS	BIT		I/O FUNCTION
Port 5	ØE9H	Ø	-	Integrator Bit 100
Group 2, Port B		1	-	Integrator Bit 200
Mode Ø Input		2	-	Integrator Bit 400
		3	-	Integrator Bit 800
		4	-	Integrator Bit 1K
		5	-	Integrator Bit 2K
		6	-	Integrator Bit 4K
		7	-	Integrator Bit 8K
Port 6	ØEAH	Ø	-	Integrator Bit 10K
Group 2, Port C		1	-	Integrator Bit 20K
Mode Ø Input		2	-	Integrator Bit 40K
		3	-	Integrator Bit 80K
		4	-	1 minute
		5	-	10 minutes
		6	-	60 minutes
		7	-	Not Used

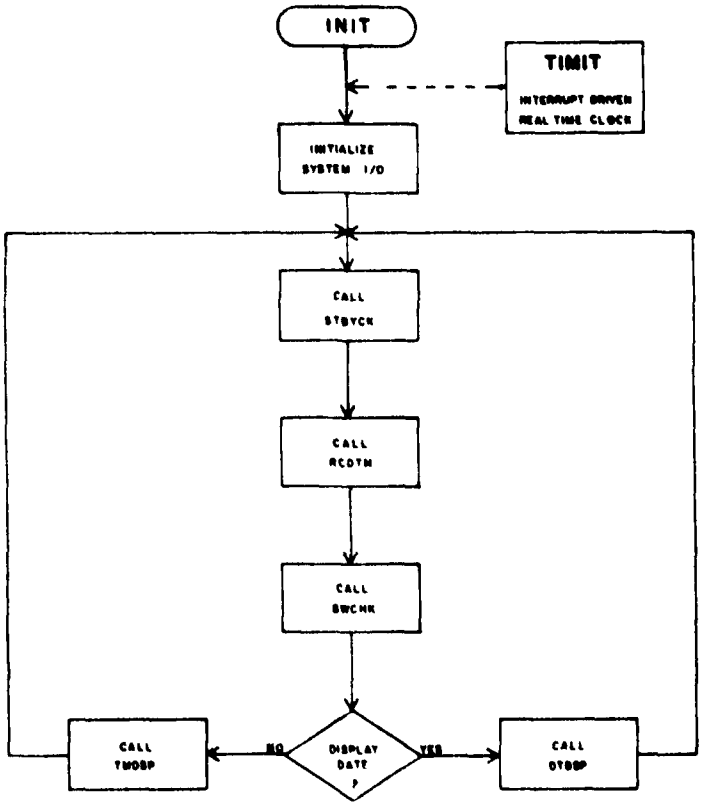
APPENDIX C

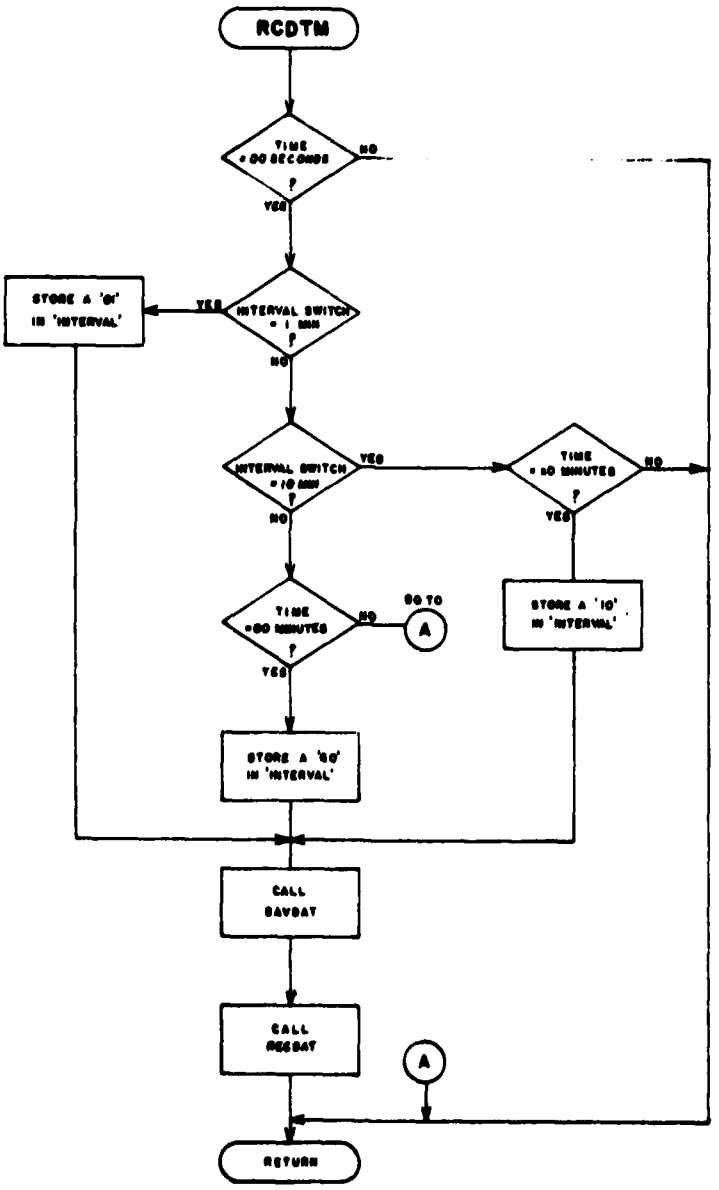
MEMORY MAP

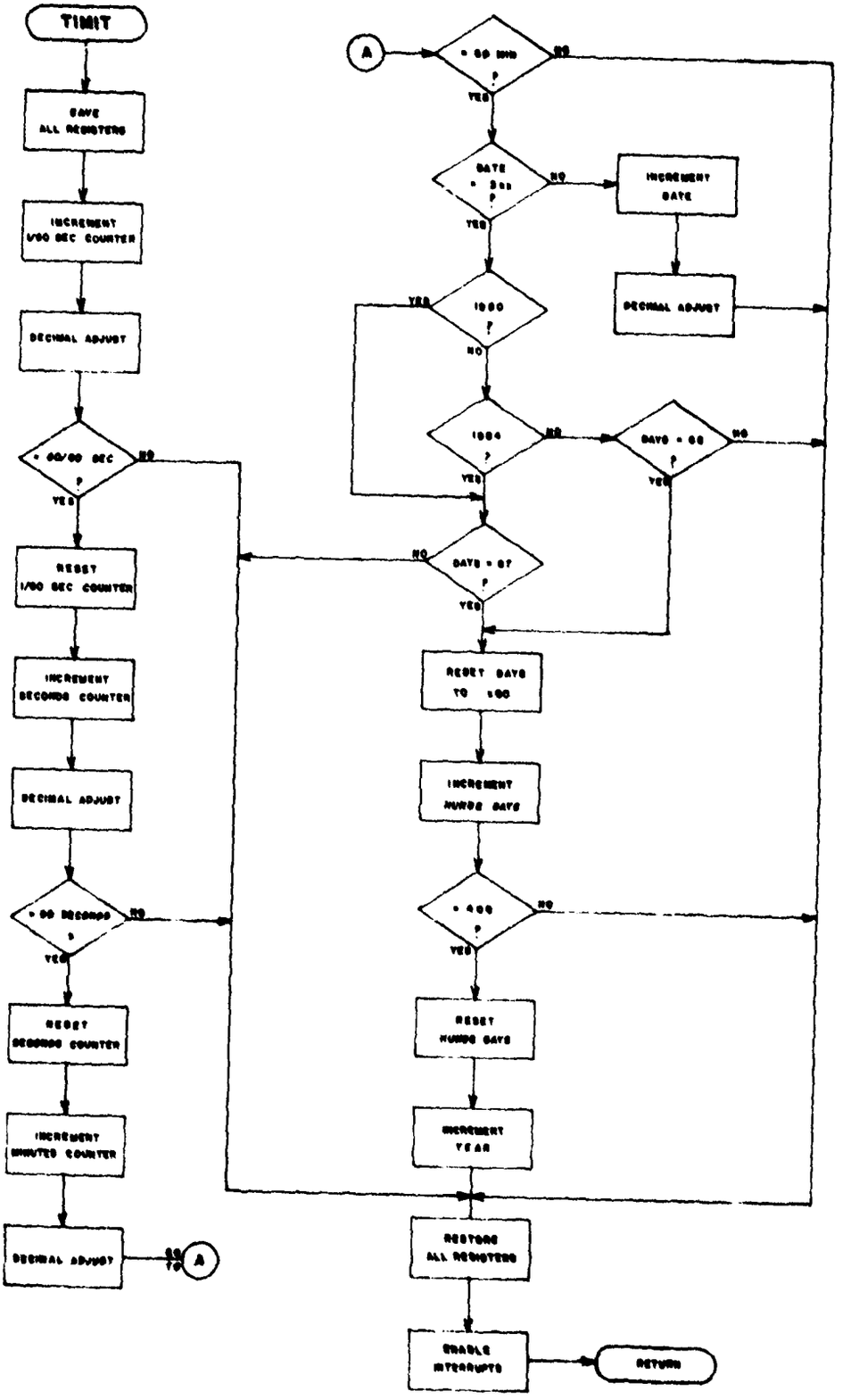
ADDRESS (HEX)	LOCATION NAME
3C00	TIMER
3C01	SEC
3C02	MIN OR TIME
3C03	HRS
3C04	LS DATE OR DATE
3C05	MSDATE
3C06	LSDATA
3C07	DATA
3C08	MSDATA
3C09	INTVL (Interval)
3C0A	Not Used
3C0B	Not Used
3C0C	STBYFL (Standby Flag)

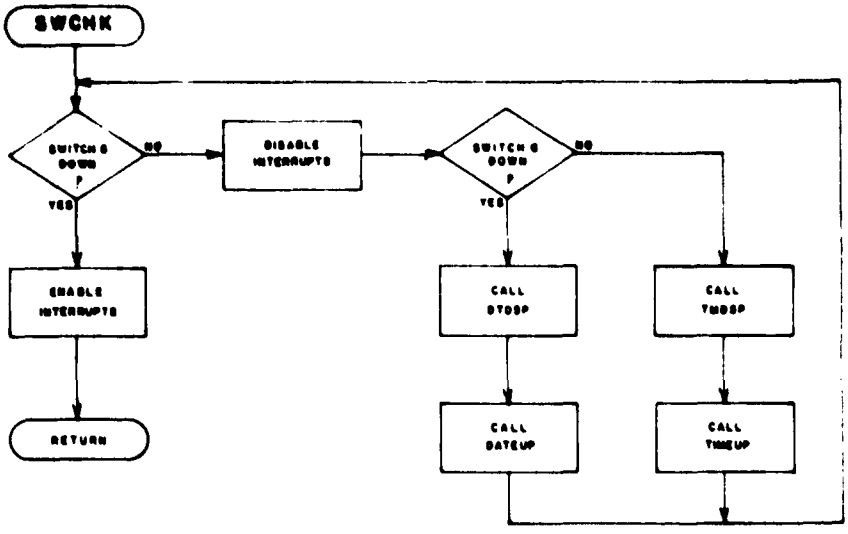
APPENDIX D

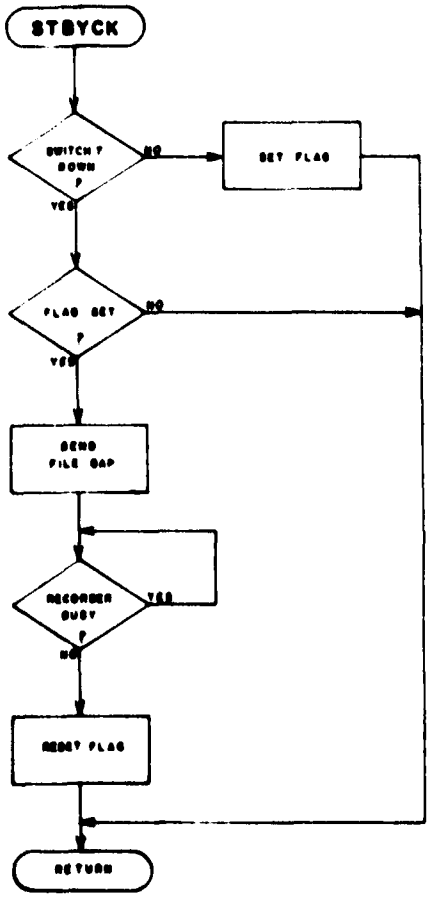
FLOWCHARTS

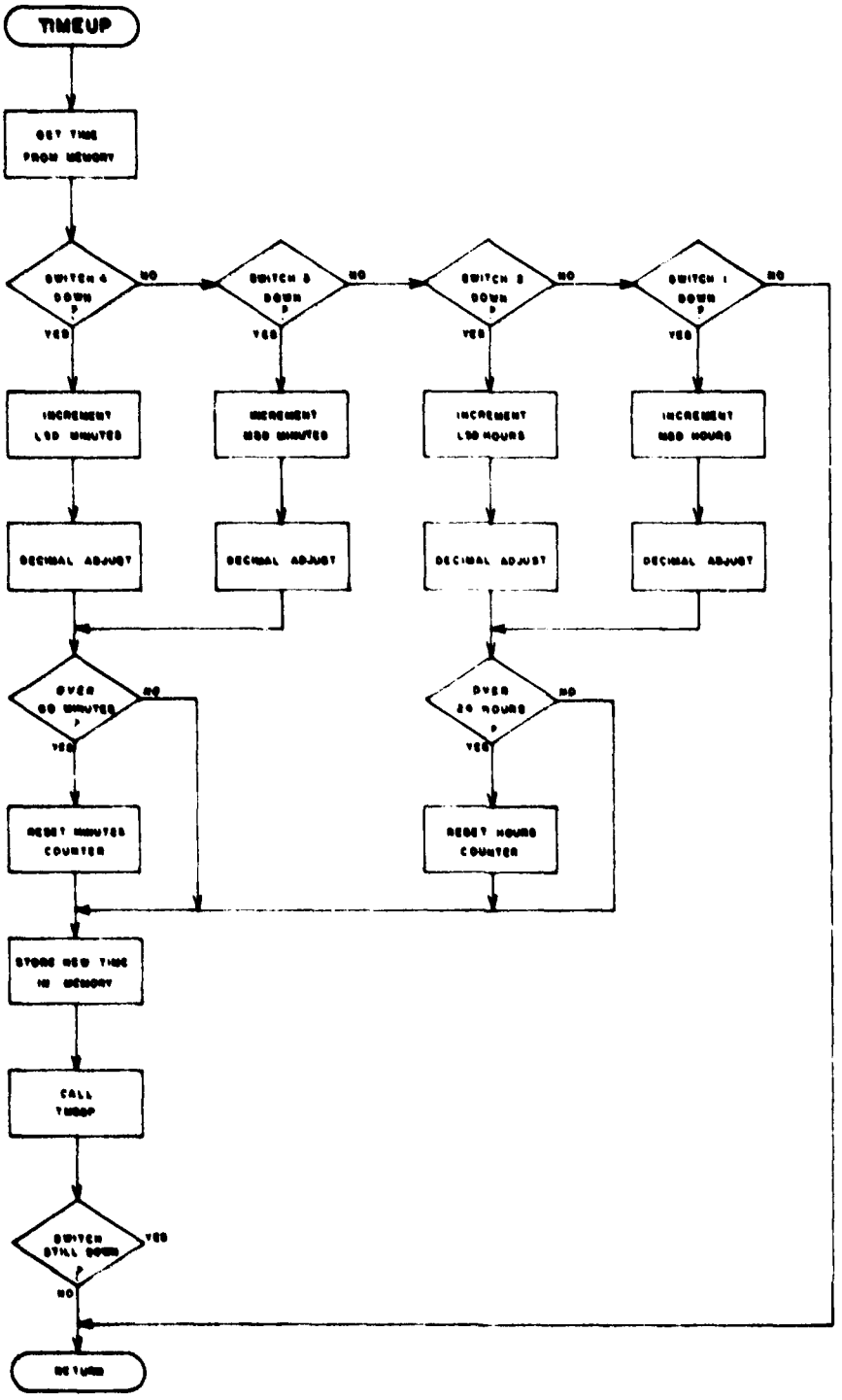


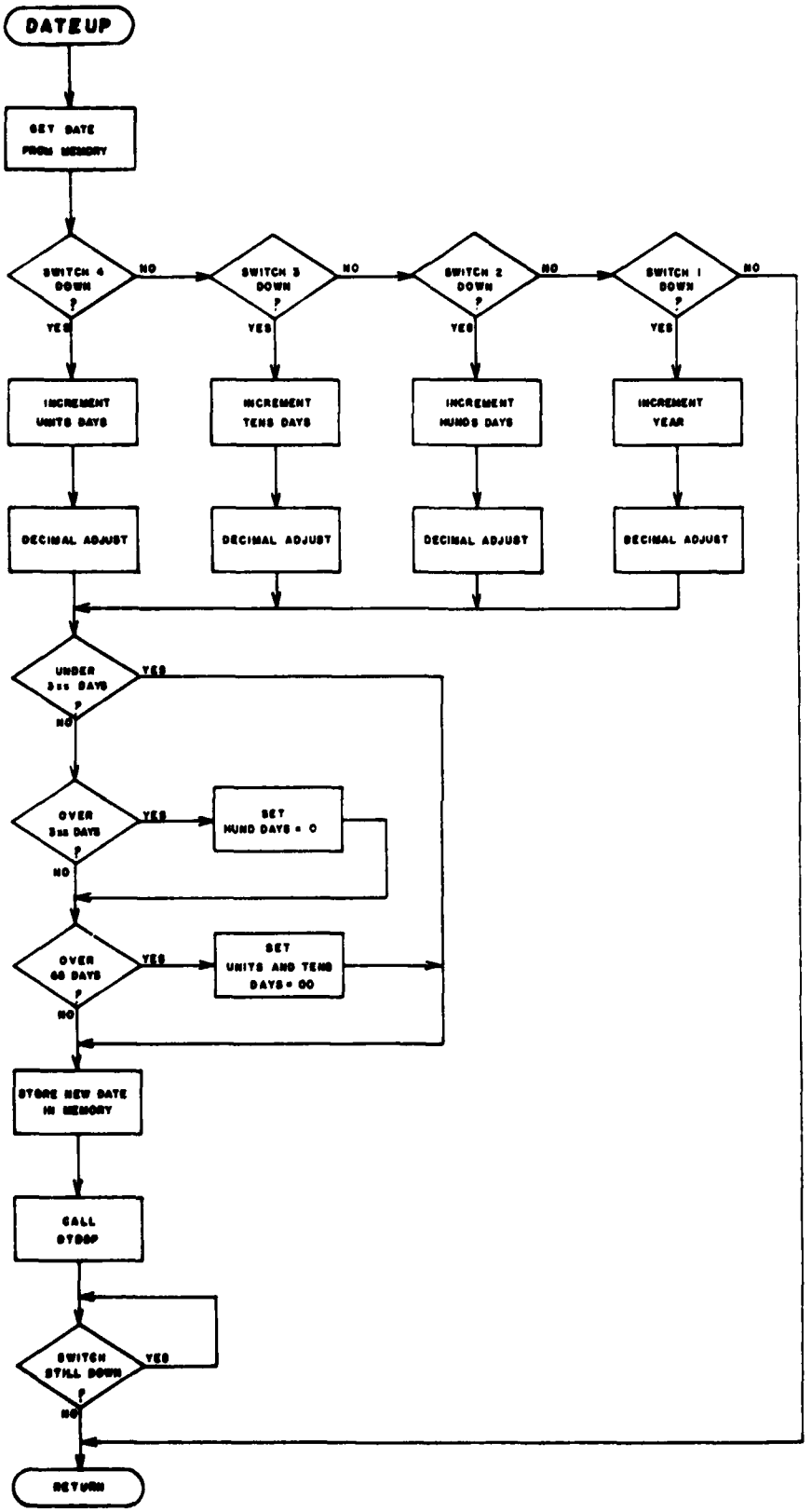

RCDTM
TIME = 00 SECONDS ?
NO
YES
INTERVAL SWITCH = 1 MIN ?
YES
STORE A '0' IN 'INTERVAL'
NO
INTERVAL SWITCH = 10 MIN ?
YES
TIME = 10 MINUTES ?
NO
YES
STORE A '10' IN 'INTERVAL'
NO
TIME = 60 MINUTES ?
NO
GO TO
A
YES
STORE A '60' IN 'INTERVAL'
CALL SAVDAT
CALL RESDAT
A
RETURN


TIMIT
SAVE ALL REGISTERS
INCREMENT 1/100 SEC COUNTER
DECIMAL ADJUST
= 00/00 SEC ?
NO
YES
RESET 1/100 SEC COUNTER
INCREMENT SECONDS COUNTER
DECIMAL ADJUST
= 00 SECONDS ?
NO
YES
RESET SECONDS COUNTER
INCREMENT MINUTES COUNTER
DECIMAL ADJUST
A
TO A
A
= 00 MIN ?
NO
YES
DATE = 1ST ?
NO
YES
INCREMENT DATE
DECIMAL ADJUST
1980 ?
YES
NO
1984 ?
NO
YES
DAYS = 60 ?
NO
YES
DAYS = 61 ?
NO
YES
RESET DAYS TO 1ST
INCREMENT NUMBER DAYS
= 366 ?
NO
YES
RESET NUMBER DAYS
INCREMENT YEAR
RESTORE ALL REGISTERS
ENABLE INTERRUPTS
RETURN


SWCHK
SWITCH 6 DOWN ?
NO
YES
DISABLE INTERRUPTS
SWITCH 6 DOWN ?
NO
YES
ENABLE INTERRUPTS
CALL STOSP
CALL TMOSP
RETURN
CALL DATEUP
CALL TIMEUP


STBYCK
SWITCH 7 DOWN ?
NO
YES
SET FLAG
FLAG SET ?
NO
YES
SEND FILE GAP
RECORDER BUSY ?
YES
NO
RESET FLAG
RETURN





APPENDIX E

SOURCE SOFTWARE

```
ISIS-II OBJECT LOCATER V3.0 INVOKED BY
-LOCATE  F1 SOLAR LNK CODE(0850H) MAP PRINT( F1 SOLMAP LST) SYMBOLS COLUMNS(3)
SYMBOL TABLE OF MODULE SOLAR

VALUE TYPE SYMBOL          VALUE TYPE SYMBOL          VALUE TYPE SYMBOL

      MOD  INIT
3C04H SYM  DATE            3C89H SYM  INTVL           00E4H SYM  PORT1
00E3H SYM  PORT2           3C82H SYM  TIME            3C88H SYM  TIMER
0850H SYM  BEGIN           0872H SYM  MAIN            0000H SYM  THERE
      MOD  RCDTM
3C89H SYM  INTVL           3C82H SYM  MIN             00E6H SYM  PORT6
3C81H SYM  SEC             00F3H SYM  AROUND          00B7H SYM  NEXT
00E3H SYM  RCDTM           00BFH SYM  RCRD            0097H SYM  THERE
      MOD  STBYCK
00E4H SYM  PORT1           00E3H SYM  PORT2           3C8CH SYM  STBYFL
0A09H SYM  SETFLG          00E3H SYM  STAY            00C9H SYM  STBYCK
00DFH SYM  STRB
      MOD  SAVDAT
3C88H SYM  DATA            00E3H SYM  PORT2           00E8H SYM  PORT4
00E3H SYM  PORT5           00E6H SYM  PORT6           00F6H SYM  SAVDAT
      MOD  TINIT
3C83H SYM  HR              3C84H SYM  LSDATE          3C82H SYM  MIN
3C85H SYM  MSDATE          3C81H SYM  SEC             3C88H SYM  TIMER
0160H SYM  DIVIT           0167H SYM  EXIT            0166H SYM  EXIT2
0152H SYM  JULDT           0140H SYM  LEAP            0170H SYM  SAVE
0112H SYM  TINIT
      MOD  SNCHK
00E4H SYM  PORT1           0180H SYM  DTTM            0170H SYM  SNCHK
0197H SYM  THERE
      MOD  TMDSP
3C82H SYM  TIME            01A8H SYM  TMDSP
      MOD  DTDSP
3C84H SYM  DATE            01A7H SYM  DTDSP
      MOD  RECDAT
3C87H SYM  DATA            3C83H SYM  HRS             3C89H SYM  INTVL
3C86H SYM  LSDATA          3C84H SYM  LSDATE          3C82H SYM  MIN
3C88H SYM  MSDATA          3C85H SYM  MSDATE          00E4H SYM  PORT1
01A8H SYM  RECDAT
      MOD  TIMEUP
00E4H SYM  PORT1           3C82H SYM  TIME            0230H SYM  DBON
0231H SYM  EXIT            021EH SYM  EXIT1           0229H SYM  EXIT2
01F0H SYM  NXT1            0204H SYM  NXT2            0212H SYM  NXT3
0225H SYM  OVER1           0238H SYM  OVER2           01E4H SYM  TIMEUP
      MOD  DATEUP
3C04H SYM  DATE            00E4H SYM  PORT1           0200H SYM  CHECK
0240H SYM  DATEUP          0259H SYM  DBON            027BH SYM  DTCHK
0253H SYM  EXIT            0253H SYM  NXT1            0262H SYM  NXT2
0271H SYM  NXT3
      MOD  DISPL
0001H SYM  DIG1            0002H SYM  DIG2            0004H SYM  DIG3
0008H SYM  DIG4            00E3H SYM  PORT2           00E8H SYM  PORT3
029AH SYM  DISPL           00C2H SYM  OUTIT
      MOD  RECORD
00E4H SYM  PORT1           00E3H SYM  PORT2           00E8H SYM  PORT3
00E5H SYM  RECDSV          00D0H SYM  RECORD
```

```
MEMORY MAP OF MODULE SOLAR
READ FROM FILE :F1:SOLAR.LNK
WRITTEN TO FILE :F1:SOLAR
MODULE IS NOT A MAIN MODULE

START   STOP LENGTH REL NAME

0000H  0002H     3H  A  ABSOLUTE
0038H  003AH     3H  A  ABSOLUTE
0058H  02ECH   290H  B  CODE
02EDH  02F8H     CH  B  STACK
02F9H  F6BFH  F3C7H  B  MEMORY
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                    1        NAME    INIT
                    2        EXTRN   TIMIT,SWCHK,TMDSP,DTDSP,SAVDAT,STBYCK,RCDTM
3C00                3        TIMER   EQU     3C00H
3C02                4        TIME    EQU     3C02H
3C04                5        DATE    EQU     3C04H
3C09                6        INTVL   EQU     3C09H
00E4                7        PORT1   EQU     0E4H
00E5                8        PORT2   EQU     0E5H
                    9 ;**************
                   10 ;       MAIN PROGRAM
                   11 ;
                   12 ;       PROGRAMMER:     STAPLETON
                   13 ;**************
                   14        RSEG
0000               15        ORG     0       ;RST 0, GENERATED ON POWER-UP
0000 C30000    C   16        JMP     BEGIN
0038               17        ORG     38H     ;RST 1, GENERATED BY INTERUPT 1
0038 C30000    E   18        JMP     TIMIT
                   19        CSEG
                   20 BEGIN:
0000 3E90          21        MVI     A,90H   ;SET UP GROUP A, PORT 1,INPUT; 2 & 3 OUTPUT
0002 D3E7          22        OUT     0E7H
0004 21FF3C        23        LXI     H,3CFFH ;INIT STACK LOCATION
0007 F9            24        SPHL
0008 110000        25        LXI     D,00H   ;INIT DISPLAY
000B 210000        26        LXI     H,00H   ;
000E 22003C        27        SHLD    TIMER   ;INIT SEC'S & MSEC'S
0011 22023C        28        SHLD    TIME    ;INIT MEM TIME
0014 22043C        29        SHLD    DATE    ;INIT DATE, ALSO
0017 22093C        30        SHLD    INTVL   ;INIT INTVL
001A 3E60          31        MVI     A,60H   ;RESET INTEGRATOR, SET FILE GAP HI
001C D3E5          32        OUT     PORT2
001E 3E00          33        MVI     A,00H   ;RETURN RESET LINE HI,SET FILE GAP LO
0020 D3E5          34        OUT     PORT2
                   35 MAIN:
0022 CD0000    E   36        CALL    STBYCK
0025 CD0000    E   37        CALL    RCDTM
0028 CD0000    E   38        CALL    SWCHK
002B DBE4          39        IN      PORT1
002D E602          40        ANI     02H     ;MASK FOR DATE/TIME SWITCH
002F C23300    C   41        JNZ     THERE   ;SET TO TIME, JUMP OVER 'DISLAY DATE'
0032 CD0000    E   42        CALL    DTDSP   ;SET TO DATE, DISPLAY IT
0035 C32200    C   43        JMP     MAIN    ;LOOP FOREVER
                   44 THERE:
0038 CD0000    E   45        CALL    TMDSP   ;DISPLAY TIME
003B C32200    C   46        JMP     MAIN    ;LOOP FOREVER
                   47        END
```

```
LOC  OBJ          SEQ         SOURCE STATEMENT

                    1         NAME    RCDTM
                    2         PUBLIC  RCDTM
                    3         EXTRN   SAVDAT,RECDAT
3C81                4         SEC     EQU     3C81H
3C82                5         MIN     EQU     3C82H
3C89                6         INTVL   EQU     3C89H
00EA                7         PORT6   EQU     0EAH
                    8 ;***********
                    9 ;       THIS ROUTINE CHECKS THE TIME AND AT SEC=00
                   10 ;       RECORDS THE DATA CALLED FOR ELSEWHERE IF THE
                   11 ;       TIME MATCHES THE INTERVAL OF THE SWITCH ON THE
                   12 ;       INTEGRATOR.
                   13 ;
                   14 ;       REGISTERS:      A,B
                   15 ;       MEMORY:         INTVL,RCFLG,INTVL
                   16 ;       STACK SPACE:    2 BYTES
                   17 ;       INPUT PORTS:    PORT 6
                   18 ;       OUTPUT PORTS:   NONE
                   19 ;       PROGRAMMER:     STAPLETON
                   20 ;***********
                   21         CSEG
                   22 RCDTM:
0000 3A813C        23         LDA     SEC     ;GET SECONDS
0003 FE00          24         CPI     00H     ;SEE IF 00
0005 CA0900    C   25         JZ      THERE   ;=00, CHECK INTERVAL SWITCH
0008 C9            26         RET             ;ELSE RETURN
                   27 ;
                   28 THERE:
0009 DBEA          29         IN      PORT6   ;ELSE, SCAN INTERVAL SW ON INTEGRATOR
000B E610          30         ANI     10H     ;1 MIN POSITION MASK
000D C21500    C   31         JNZ     AROUND  ;NOT ONE MIN, PRESS ON
0010 3E01          32         MVI     A,01    ;1 MIN
0012 C33100    C   33         JMP     RCRD    ;THEN START RECORDING
                   34 AROUND:
0015 DBEA          35         IN      PORT6   ;GET ANOTHER COPY OF INTERVAL SW
0017 E620          36         ANI     20H     ;MASK FOR 10 MIN INTERVAL
0019 C22900    C   37         JNZ     NEXT    ;NOT 10 MIN,GO CHECK 60 MINS
001C 3A823C        38         LDA     MIN     ;GET MINUITS
001F E60F          39         ANI     0FH     ;MASK OFF TENS
0021 FE00          40         CPI     00H     ;CHECK FOR MINS = X0
0023 C0            41         RNZ             ;NOT = X0, RETURN
0024 3E10          42         MVI     A,10H   ;PUT A 10 IN ACC FOR STORING IN INTVL
0026 C33100    C   43         JMP     RCRD    ;GO RECORD
                   44 NEXT:
0029 3A823C        45         LDA     MIN     ;GET TIME
002C FE00          46         CPI     00H     ;WHEN MINS = 00 TIME TO RECORD
002E C0            47         RNZ
002F 3E60          48         MVI     A,60H
                   49 RCRD:
0031 32893C        50         STA     INTVL   ;STORE INTERVAL FOR RECORDING
0034 CD0000    E   51         CALL    SAVDAT  ;GET DATA, STORE IT, AND RESET INTEGRATOR
0037 CD0000    E   52         CALL    RECDAT  ;THEN RECORD DATA, DATE, TIME ET ALL
003A C9            53         RET             ;THEN RETURN
                   54 END
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

                    1        NAME   RECDAT
                    2        PUBLIC RECDAT
                    3        EXTRN  RECORD
00E4                4        PORT1  EQU    0E4H
3C05                5        MSDATE EQU    3C05H
3C04                6        LSDATE EQU    3C04H
3C03                7        HRS    EQU    3C03H
3C02                8        MIN    EQU    3C02H
3C08                9        MSDATA EQU    3C08H
3C07               10        DATA   EQU    3C07H
3C06               11        LSDATA EQU    3C06H
3C09               12        INTVL  EQU    3C09H
                   13 ;**********
                   14 ;       THIS ROUTINE CHECKS THE RUN/STANDBY SWITCH
                   15 ;       SETTING THEN RECORDS DATA IN THE PROPER SEQUENSE
                   16 ;       BY LOADING THE DATA INTO THE ACCUM AND CALLING
                   17 ;       THE RECORD SUBROUTINE.
                   18 ;
                   19 ;       REGISTERS:      A
                   20 ;       MEMORY:         NONE
                   21 ;       STACK SPACE:    1 BYTE
                   22 ;       INPUT PORTS:    PORT 1
                   23 ;       OUTPUT PORTS:   NONE
                   24 ;       PROGRAMMER:     STAPLETON
                   25 ;**********
                   26         CSEG
                   27 RECDAT:
0000 DBE4          28         IN     PORT1   ;SW PORT
0002 E640          29         ANI    40H     ;MASK FOR STBY SW
0004 C8            30         RZ             ;IN STBY, RETURN
                   31 ;
0005 3A053C        32         LDA    MSDATE  ;ELSE START RECORDING SEQUENCE
0008 CD0000    E   33         CALL   RECORD
000B 3A043C        34         LDA    LSDATE
000E CD0000    E   35         CALL   RECORD
0011 3A033C        36         LDA    HRS
0014 CD0000    E   37         CALL   RECORD
0017 3A023C        38         LDA    MIN
001A CD0000    E   39         CALL   RECORD
001D 3A083C        40         LDA    MSDATA
0020 CD0000    E   41         CALL   RECORD
0023 3A073C        42         LDA    DATA
0026 CD0000    E   43         CALL   RECORD
0029 3A063C        44         LDA    LSDATA
002C CD0000    E   45         CALL   RECORD
002F 3A093C        46         LDA    INTVL
0032 CD0000    E   47         CALL   RECORD
0035 C9            48         RET
                   49         END
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

                    1        NAME   RECORD
                    2        PUBLIC RECORD
00E4                3        PORT1  EQU    0E4H
00E5                4        PORT2  EQU    0E5H
00E6                5        PORT3  EQU    0E6H
                    6 ;*************
                    7 ;      RECORD ROUTINE
                    8 ;      THIS ROUTINE SENDS ONE
                    9 ;      BYTE OF DATA TO THE RECORDER,
                   10 ;      THEN SENDS A 'RECORD' STROBE.
                   11 ;      DATA MUST BE IN THE ACCUMULATOR
                   12 ;      PRIOR TO CALLING THIS PROGRAM.
                   13 ;
                   14 ;      REGISTERS:      A
                   15 ;      MEMORY:         NONE
                   16 ;      STACK SPACE:    NONE
                   17 ;      INPUT PORTS:    PORT 1
                   18 ;      OUTPUT PORTS:   PORT 2
                   19 ;      PROGRAMMER:     MANTZ
                   20 ;*************
                   21        CSEG
                   22 RECORD:
0000 2F            23        CMA             ;INVERT DATA TO CORRECT
0001 D3E6          24        OUT     PORT3
                   25 ;
                   26 ;      STROBE TO START RECORDING
                   27 ;
0003 DBE5          28        IN      PORT2
0005 F680          29        ORI     80H
0007 D3E5          30        OUT     PORT2
0009 E67F          31        ANI     7FH
000B D3E5          32        OUT     PORT2
                   33 ;
                   34 ;      MONITOR THE BUSY BIT
                   35 ;
000D DBE4          36 RECBSY: IN      PORT1
000F E680          37        ANI     80H     ;MASK BUSY BIT
0011 C20D00    C   38        JNZ     RECBSY  ;LOOP UNTIL DONE
0014 C9            39        RET             ;THEN RETURN
                   40        END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1        NAME   STBYCK
                  2        PUBLIC STBYCK
3C8C              3        STBYFL EQU    3C8CH
00E4              4        PORT1  EQU    0E4H
00E5              5        PORT2  EQU    0E5H
                  6 ;**************
                  7 ;      STANDBY/RUN SWITCH CHECK
                  8 ;
                  9 ;      THIS ROUTINE CHECKS THE STATUS OF THE RUN/STANDBY SWITCH
                 10 ;      AND GENERATES A FILE GAP COMMAND UPON THE TRANSITION
                 11 ;      FROM STANDBY TO RUN.  THIS IN TURN RESETS THE RECORDER
                 12 ;      WORD COUNTER
                 13 ;
                 14 ;      REGISTERS:      A
                 15 ;      MEMORY:         STBYFL  (STANDBY FLAG = FF IN STBY)
                 16 ;      STACK SPACE:    NONE
                 17 ;      INPUT PORTS:    PORTS 1,2
                 18 ;      OUTPUT PORTS:   PORT 2
                 19 ;      PROGRAMMER:     STAPLETON
                 20 ;**************
                 21        CSEG
                 22 STBYCK:
0000 DBE4        23        IN     PORT1   ;STBY/RUN SW INPUT PORT
0002 E640        24        ANI    40H     ;MASK FOR SW
0004 CA1800   C  25        JZ     SETFLG  ;NOT RUN, SET FLAG
0007 3A8C3C      26        LDA    STBYFL  ;RUN, GET FLAG
000A F600        27        ORI    00H     ;SEE IF SET
000C C21600   C  28        JNZ    STRB    ;IN 'RUN' AND FLAG SET, SEND STROBE
000F C9          29        RET            ;OTHERWISE RETURN
                 30 SETFLG:
0010 3EFF        31        MVI    A,0FFH  ;STANDBY = FF
0012 328C3C      32        STA    STBYFL  ;STORE IT
0015 C9          33        RET            ;THEN RETURN
                 34 STRB:
0016 DBE5        35        IN     PORT2   ;GET COPY OF STROBE PORT
0018 F620        36        ORI    20H     ;SET FILE GAP STROBE HI
001A D3E5        37        OUT    PORT2   ;SEND IT TO RECORDER
001C E6DF        38        ANI    0DFH    ;RETURN STROBE LOW
001E D3E5        39        OUT    PORT2   ;SEND IT
                 40 STAY:
0020 DBE4        41        IN     PORT1   ;BUSY BIT INPUT PORT
0022 E600        42        ANI    00H     ;BUSY BIT MASK
0024 C22000   C  43        JNZ    STAY    ;LOOP HERE UNTIL DONE, THEN
0027 3E00        44        MVI    A,00H   ;RESET STRBFL TO 00,
0029 328C3C      45        STA    STBYFL  ;AND STORE IT
002C C9          46        RET            ;THEN RETURN
                 47 ;
                 48 END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1                NAME    SAVDAT
                  2                PUBLIC  SAVDAT
3C06              3        DATA    EQU     3C06H
00E5              4        PORT2   EQU     0E5H
00E8              5        PORT4   EQU     0E8H
00E9              6        PORT5   EQU     0E9H
00EA              7        PORT6   EQU     0EAH
                  8 ;**************
                  9 ;       SAVE DATA
                 10 ;
                 11 ;       THIS ROUTINE READS THE OUTPUT OF THE INTEGRATOR
                 12 ;       AND STORES IT IN THREE MEMORY LOCATIONS STARTING
                 13 ;       AT DATA.  IT ALSO RESETS THE INTEGRATOR TO ZERO.
                 14 ;
                 15 ;       REGISTERS:      ACC
                 16 ;       MEMORY:         3 BYTES
                 17 ;       STACK SPACE:    NONE
                 18 ;       INPUT PORTS:    PORTS 2,4,5,6
                 19 ;       OUTPUT PORTS:   PORT 2
                 20 ;       PROGRAMMER:     STAPLETON
                 21 ;*************
                 22        CSEG
                 23 ;
0000 DBE8        24 SAVDAT: IN      PORT4   ;READ L.S DIGITS OF INTEGRATOR
0002 323C3C      25         STA     DATA    ;STORE IT IN MEMORY 'DATA'
0005 DBE9        26         IN      PORT5
0007 323D3C      27         STA     DATA+1
000A DBEA        28         IN      PORT6
000C E60F        29         ANI     0FH     ;MASK OFF UPPER BITS
000E 323E3C      30         STA     DATA+2
0011 DBE5        31         IN      PORT2   ;GET COPY OF PORT 2
0013 F640        32         ORI     40H     ;MASK OFF ALL BUT INTEGR RESET BIT
0015 D3E5        33         OUT     PORT2   ;RESET INTEGRATOR
0017 E6BF        34         ANI     0BFH    ;SET BIT 7 HI
0019 D3E5        35         OUT     PORT2   ;RETURN INTEGR TO COUNTING
001B C9          36         RET             ;RETURN TO CALLING PRGM
                 37         END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                    1        NAME   TIMIT
                    2        PUBLIC TIMIT
3C85                3        MSDATE EQU    3C85H   ;LO ORDER DIGIT OF YEAR
                    4                               ; AND HI ORDER DIGIT OF DATE
3C84                5        LSDATE EQU    3C84H   ;LOW ORDER DIGITS OF DATE
3C83                6        HR     EQU    3C83H   ;HOURS
3C82                7        MIN    EQU    3C82H   ;MINUTES
3C81                8        SEC    EQU    3C81H   ;SECONDS
3C80                9        TIMER  EQU    3C80H   ;60THS OF SECONDS
                   10 ;**********
                   11 ;       INTERRUPT DRIVEN REAL TIME CLOCK
                   12 ;
                   13 ;       THIS ROUTINE IS A SOFTWARE, INTERRUPT
                   14 ;       DRIVEN JULIAN DATE CALENDER AND REAL TIME
                   15 ;       CLOCK.  IT IS A BORROWED PROGRAM THAT HAS
                   16 ;       BEEN SLIGHTLY MODIFIED.  THE ORIGINAL
                   17 ;       VERSION CAN BE FOUND IN INSITE, REF. NO. 024,
                   18 ;       PG. 7-69.
                   19 ;
                   20 ;       REGISTERS:      NONE, ALL STATUS SAVED
                   21 ;       MEMORY:         TIMER, SEC, MIN, HR,
                   22 ;                       LSDATE,MSDATE
                   23 ;       STACK SPACE:    2 BYTES
                   24 ;       INPUT PORTS:    NONE
                   25 ;       OUTPUT PORTS:   NONE
                   26 ;       PROGRAMMER:     STEVE BECQUER
                   27 ;**********
                   28        CSEG
                   29 TIMIT:
0000 F5            30        PUSH   PSW     ;SAVE STATUS AND REGISTERS
0001 C5            31        PUSH   B       ;OF INTERRUPTED ROUTINE.
0002 D5            32        PUSH   D       ;
0003 113C0C        33        LXI    D,TIMER ;GET ADDRESS OF TIME COUNTERS (60THS OF SEC).
0006 0660          34        MVI    B,60H   ;SET MODULO TO 60.
0008 0E00          35        MVI    C,0     ;SET STARTING COUNT TO 0.
000A CD5A00    C   36        CALL   DIVIT   ;UPDATE 60THS OF SEC COUNTER.
000D 0660          37        MVI    B,60H   ;SET MODULO TO 60.
000F CD5A00    C   38        CALL   DIVIT   ;UPDATE SECONDS COUNTER.
0012 CD5A00    C   39        CALL   DIVIT   ;UPDATE MINUTES COUNTER.
0015 0624          40        MVI    B,24H   ;SET MODULO TO 24.
0017 CD5A00    C   41        CALL   DIVIT   ;UPDATE HOURS COUNTER.
001A 113E0C        42        LXI    D,MSDATE
001D 0600          43        MVI    B,00H   ;SET MODULO 100
001F 1A            44        LDAX   D       ;LOAD COUNT(YR&MSDATE)
0020 E60F          45        ANI    0FH     ;MASK OFF YEAR, LEAVE HD DAYS
0022 FE03          46        CPI    03H     ;3HD DAYS?
0024 C22800    C   47        JNZ    JULDT   ;NO, GO INCR LS DATE
0027 1A            48        LDAX   D       ;GET ANOTHER COPY OF YR&MSDATE
0028 0E01          49        MVI    C,01H   ;START COUNT DAYS FR 001
002A E6F0          50        ANI    0F0H    ;MASK OFF HD DAYS
002C FE00          51        CPI    00      ;1900
002E CA3000        52        JZ     LEAP
```

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0831 FE28          53          CPI     40      ;1984
0833 CA3800        54          JZ      LEAP
0836 0666          55          MVI     B,66H   ;NOT LEAP, RESETS AT 66
0838 C34000    C   56          JMP     JULDT   ;UPDATE DATE
083B 0667          57 LEAP:    MVI     B,67H   ;LEAP YEAR,RESETS AT 67
083D C34000    C   58          JMP     JULDT
                   59 JULDT:
0840 1B            60          DCX     D       ;POINT TO LS DATE
0841 CD5A00    C   61          CALL    DIVIT   ;UPDATE LS DATE COUNTER
0844 0604          62          MVI     B,04H   ;RESETS WHEN MS DATE=4
0846 1A            63          LDAX    D       ;GET MS DATE
0847 3C            64          INR     A       ;INCR IT
0848 12            65          STAX    D       ;STORE A COPY, AND
0849 A0            66          ANA     B       ;MASK YEAR WHILE COMPARING TO 4 HD DAYS
084A B8            67          CMP     B       ;ACC = 0 IF  400 DAYS
084B C25400    C   68          JNZ     EXIT2   ;NOT OVER 365 OR 366
084E 1A            69          LDAX    D       ;DAYS = 4XX,READY RESET
084F E6F8          70          ANI     0F8H    ;RESET HD DAYS ,LEAVE YEAR ALONE
0851 C618          71          ADI     18H     ;ADD 1 TO YEAR
0853 12            72          STAX    D       ;STORE NEW
                   73 EXIT2:
0854 D1            74          POP     D       ;DUMMY RETURN
                   75 EXIT:
0855 D1            76          POP     D       ;RESTORE REGISTERS.
0856 C1            77          POP     B       ;
0857 F1            78          POP     PSW     ;RESTORE STATUS.
0858 FB            79          EI              ;ENABLE FURTHER INTERRUPTS.
0859 C9            80          RET             ;RETURN TO INTERRUPTED ROUTINE.
                   81 DIVIT:                   ;VARIBLE MODULO COUNTER.
085A 1A            82          LDAX    D       ;LOAD COUNTER TO BE INCREMENTED INTO ACC.
085B 37            83          STC             ;
085C 3F            84          CMC             ;CLEAR CARRY BY SETTING IT
                   85                          ;AND THEN COMPLEMENTING IT.
085D 3C            86          INR     A       ;INCREMENT COUNT.
085E 27            87          DAA             ;DECIMAL ADJUST.
085F B8            88          CMP     B       ;TEST IF RESET COUNT
                   89                          ;HAS BEE REACHED.
0860 C26400    C   90          JNZ     SAVE    ;IF NOT REACHED,
                   91                          ;SAVE COUNT AND EXIT.
0863 79            92          MOV     A,C     ;RESET TO STARTING COUNT.
                   93 SAVE:
0864 12            94          STAX    D       ;RETURN COUNT TO MEMORY.
0865 13            95          INX     D       ;POINT TO NEXT COUNTER.
0866 C8            96          RZ              ;IF RESET OCCURED,
                   97                          ;GO UPDATE NEXT COUNTER.
0867 D1            98          POP     D       ;IF NOT, ISSUE A DUMMY RETURN.
0868 C35500    C   99          JMP     EXIT    ;EXIT DIVIT.
                  100          END
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

                     1        NAME   SWCHK
                     2        PUBLIC SWCHK
                     3        EXTRN  DATEUP,TIMEUP,DTDSP,TMDSP
00E4                 4        PORT1  EQU    0E4H
                     5 ;**********
                     6 ;      SWITCH CHECK
                     7 ;      CHECKS FRONT PANEL SWITCHES FOR RUN/SET,
                     8 ;      DATE/TIME.  CALLS APPROPIATE ROUTINE.
                     9 ;      REGISTERS:      A
                    10 ;      MEMORY:         NONE
                    11 ;      STACK SPACE:    2 BYTES
                    12 ;      INPUT PORTS:    PORT 1
                    13 ;      OUTPUT PORTS:   NONE
                    14 ;      PROGRAMMER:     STAPLETON
                    15 ;**********
                    16 CSEG
                    17 ;
0000 DBE4           18 SWCHK:  IN     PORT1   ;SW INPUT PORT
0002 E601           19         ANI    01H     ;MASK FOR RUN/SET, SW-5
0004 CA0900    C    20         JZ     DTTM    ;NOT RUN, GO SET DATE/TIME
0007 FB             21         EI             ;ENABLE INTERUPT FOR CLOCK
0008 C9             22         RET            ;RUN, RETURN TO CALLING PROGRAM
                    23 DTTM:
0009 F3             24         DI             ;DISABLE INTERUPTS, STOP CLOCK
000A DBE4           25         IN     PORT1   ;GET ANOTHER COPY OF PORT
000C E602           26         ANI    02H     ;MASK FOR DATE/TIME
000E C21A00    C    27         JNZ    THERE   ;GO UPDATE TIME
0011 CD0000    E    28         CALL   DTDSP   ;DISPLAY DATE
0014 CD0000    E    29         CALL   DATEUP  ;UPDATE IT
0017 C30000    C    30         JMP    SWCHK   ;CHECK SWITCHES UNTIL RUN
                    31 THERE:
001A CD0000    E    32         CALL   TMDSP
001D CD0000    E    33         CALL   TIMEUP
0020 C30000    C    34         JMP    SWCHK
                    35         END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1        NAME   TIMEUP
                  2        PUBLIC TIMEUP
                  3        EXTRN  TMDSP
3C82              4        TIME   EQU    3C82H
00E4              5        PORT1  EQU    0E4H
                  6 ;**************
                  7 ;      TIME UPDATE
                  8 ;      THIS ROUTINE CHECKS THE BUTTONS UNDER THE
                  9 ;      FRONT PANEL DISPLAY AND INCREMENTS THAT
                 10 ;      DIGIT EACH TIME THE BUTTON IS DEPRESSED.
                 11 ;      CALLS TMDSP AND DISPLAYS NEW TIME.
                 12 ;
                 13 ;      DIG 1   DIG 2   DIG 3   DIG 4
                 14 ;      MS HR   LS HR   MS MIN  LS MIN
                 15 ;      ----    -----   ------  ------
                 16 ;      SW 1    SW 2    SW 3    SW 4
                 17 ;
                 18 ;      REGISTERS:      A,D,E,H,L
                 19 ;      MEMORY:         TIME (2 BYTES)
                 20 ;      STACK SPACE:    2 BYTES
                 21 ;      INPUT PORTS:    PORT 1
                 22 ;      OUTPUT PORTS:   NONE
                 23 ;      PROGRAMMER:     STAPLETON
                 24 ;**************
                 25        CSEG
                 26 TIMEUP:
0000 2A823C      27        LHLD   TIME    ;HRS & MINS TO HAL
0003 EB          28        XCHG           ;PUT INTO DAE
0004 DBE4        29        IN     PORT1   ;GET COPY OF BUTTON INPUT PORT
0006 E620        30        ANI    20H     ;MASK OFF FOR SW-4,LSD MINS
0008 CA1200   C  31        JZ     NXT1    ;NOT THIS BUTTON, PRESS ON
000B 7B          32        MOV    A,E     ;BUTTON DOWN,PUT MINS INTO ACC
000C C601        33        ADI    01H     ;ADD 1
000E 27          34        DAA            ;DECIMAL ADJUST (WILL INCR NEXT DIGIT)
000F C3F800   C  35        JMP    EXIT1
0012 DBE4        36 NXT1:  IN     PORT1   ;GET ANOTHER COPY OF PORT1
0014 E610        37        ANI    10H     ;MASK FOR SW-3,MSD MINS
0016 CA2000   C  38        JZ     NXT2    ;NOT DOWN, PRESS ON
0019 7B          39        MOV    A,E     ;BUTTON DOWN, MOVE MINS INTO ACC
001A C610        40        ADI    10H     ;INCREMENT MSD MINS BY 1
001C 27          41        DAA            ;DECIMAL ADJUST. DISREGARD CARYOUT
001D C3F800   C  42        JMP    EXIT1   ;NOW EXIT
0020 DBE4        43 NXT2:  IN     PORT1
0022 E608        44        ANI    08H     ;MASK FOR SW-2, LSD HRS
0024 CA2E00   C  45        JZ     NXT3    ;NOT DOWN
0027 7A          46        MOV    A,D     ;BUTTON DOWN,MOVE HRS INTO ACC
0028 C601        47        ADI    01H     ;ADD 1
002A 27          48        DAA
002B C34500   C  49        JMP    EXIT2
002E DBE4        50 NXT3:  IN     PORT1
0030 E604        51        ANI    04H     ;SW-1
0032 C8          52        RZ             ;RET TO CALLING PGRM,NO BUTTONS DOWN
0033 7A          53        MOV    A,D
0034 C610        54        ADI    10H
```

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0836 27          55          DAA
0837 C34500   C  56          JMP     EXIT2
               57 EXIT1:
083A FE60        58          CPI     60H     ;MODULO 60 MINS
083C FA4100   C  59          JM      OVER1   ;LESS THAN 60
083F 3E00        60          MVI     A,00H   ;RESET TO 00 IF 60 MINS OR MORE
0841 5F          61 OVER1:   MOV     E,A     ;RETURN MINS TO E REGISTER
0842 C34800   C  62          JMP     EXIT
               63 EXIT2:
0845 FE24        64          CPI     24H     ;MODULO 24 HRS
0847 FA4C00   C  65          JM      OVER2   ;LESS THAN 24
084A 3E00        66          MVI     A,00H   ;RESET TO 00 IF 24 OR MORE
084C 57          67 OVER2:   MOV     D,A     ;RETURN HRS TO D REGISTER
               68 ;
               69 EXIT:
084D EB          70          XCHG            ;PUT TIME IN H&L
084E 22823C      71          SHLD    TIME    ;PUT TIME IN MEMORY
0851 CD0000   E  72          CALL    TMDSP   ;DISPLAY NEW TIME
0854 DBE4        73 DBON:    IN      PORT1   ;GET ANOTHER COPY OF PORT 1
0856 E63C        74          ANI     3CH     ;MASK FOR SWITCHES STILL DOWN
0858 C25400   C  75          JNZ     DBON    ;WAIT FOR SW TO BE RELEASED
085B C9          76          RET             ;RETURN TO CALLING PROGRAM
               77 ;
               78 END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1        NAME   DATEUP
                  2        PUBLIC DATEUP
                  3        EXTRN  DTDSP
3CB4              4        DATE   EQU    3CB4H
00E4              5        PORT1  EQU    0E4H
                  6 ;**********
                  7 ;      JULIAN DATE UPDATE
                  8 ;      THIS ROUTINE CHECKS THE BUTTONS UNDER THE
                  9 ;      FRONT PANEL DISPLAY AND INCREMENTS THAT
                 10 ;      DIGIT EACH TIME THE BUTTON IS DEPRESSED.
                 11 ;      CALLS DTDSP AND DISPLAYS NEW DATE.
                 12 ;
                 13 ;NOTE:  CONTAINS NO PROVISION FOR MANUALLY SETTING
                 14 ;      366 DAYS IN LEAP YEAR.  ONLY DEC 31 AFFECTED,
                 15 ;      AND WHO WORKS NEW YEARS EVE?
                 16 ;
                 17 ;      DIG 1    DIG 2    DIG 3    DIG 4
                 18 ;      LS YEAR  HD DATE  TN DATE  UN DATE
                 19 ;      -------  -------  -------  -------
                 20 ;       SW 1     SW 2     SW 3     SW 4
                 21 ;
                 22 ;      REGISTERS:      A,D,E,H,L,
                 23 ;      MEMORY:         DATE (2 BYTES)
                 24 ;      STACK SPACE:    2 BYTES
                 25 ;      INPUT PORTS:    PORT 1
                 26 ;      OUTPUT PORTS:   NONE
                 27 ;      PROGRAMMER:     STAPLETON
                 28 ;**********
                 29        CSEG
                 30 ;
                 31 DATEUP:
0000 2A043C      32        LHLD   DATE    ;JULIAN DATE INTO HAL
0003 EB          33        XCHG           ;PUT INTO DE
0004 DBE4        34        IN     PORT1   ;GET COPY OF BUTTON INPUT PORT
0006 E620        35        ANI    20H     ;MASK OFF FOR SW-4, UNITS DATE
0008 CA1300   C  36        JZ     NXT1    ;NOT THIS BUTTON, PRESS ON
000B 7B          37        MOV    A,E     ;BUTTON DOWN, PUT LAST 2 OF DATE IN ACC
000C C601        38        ADI    01H     ;ADD 1
000E 27          39        DAA            ;DECIMAL ADJUST
000F 5F          40        MOV    E,A     ;RETURN IT TO E REGIS
0010 C33800   C  41        JMP    DTCHK
0013 DBE4        42 NXT1:  IN     PORT1   ;GET ANOTHER COPY OF PORT 1
0015 E610        43        ANI    10H     ;MASK FOR SW-3, TENS DATE
0017 CA2200   C  44        JZ     NXT2    ;NOT THIS BUTTON EITHER
001A 7B          45        MOV    A,E     ;BUTTON DOWN,PUT LAST 2 OF DATE IN ACC
001B C610        46        ADI    10H     ;ADD 1 TO TENS
001D 27          47        DAA
001E 5F          48        MOV    E,A
001F C33800   C  49        JMP    DTCHK
```

```
0822 DBE4          50 NXT2:  IN    PORT1
0824 E608          51        ANI   08H     ;MASK FOR SW-2
0826 CA3108    C   52        JZ    NXT3    ;NOR THIS BUTTON
0829 7A            53        MOV   A,D     ;YEAR & MND'S OF DATE TO ACC
082A C681          54        ADI   81H
082C 27            55        DAA
082D 57            56        MOV   D,A
082E C33808    C   57        JMP   DTCHK
0831 DBE4          58 NXT3:  IN    PORT1
0833 E604          59        ANI   04H     ;MASK FOR SW-1
0835 C8            60        RZ            ;NO SW'S DOWN,RETURN TO CALLING PRGM
0836 7A            61        MOV   A,D
0837 C610          62        ADI   10H
0839 27            63        DAA
083A 57            64        MOV   D,A
                   65 DTCHK:
083B 7A            66        MOV   A,D     ;YR & MSD,DATE TO ACC
083C E60F          67        ANI   0FH     ;MASK OFF UPPER BITS (YR)
083E FE03          68        CPI   03H     ;OVER 300 DAYS?
0840 FA5208    C   69        JM    EXIT    ;NO, EXIT
0843 CA4A08    C   70        JZ    CHECK   ;300, GO SEE IF OVER 365
0846 7A            71        MOV   A,D     ;OVER 300,GET ANOTHER COPY
0847 E6F0          72        ANI   0F0H    ;RESET MSD,DATE TO 00
0849 57            73        MOV   D,A     ;RETURN IT TO D
084A 7B            74 CHECK: MOV   A,E     ;GET LAST 2 DIGITS
084B FE66          75        CPI   66H     ;OVER 65? (365 DAYS PER)
084D FA5208    C   76        JM    EXIT    ;NO, EXIT
0850 1E00          77        MVI   E,00H   ;YES, RESET TO 00
                   78 ;
                   79 EXIT:
0852 EB            80        XCHG          ;PUT DATE IN HAL
0853 223A3C        81        SHLD  DATE    ;PUT DATE IN MEMORY
0856 CD0000    E   82        CALL  DTDSP   ;DISPLAY NEW DATE
0859 DBE4          83 DBON:  IN    PORT1   ;GET ANOTHER COPY OF PORT 1
085B E63C          84        ANI   3CH     ;MASK FOR SWITCHES STILL DOWN
085D C25908    C   85        JNZ   DBON    ;WAIT FOR SW TO BE RELEASED
0860 C9            86        RET           ;RETURN TO CALLING PROGRAM
                   87 ;
                   88 END
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1        NAME   TMDSP
                  2        PUBLIC TMDSP
                  3        EXTRN  DISPL
3CB2              4        TIME   EQU    3CB2H
                  5 ;**************
                  6 ;      DISPLAY TIME
                  7 ;
                  8 ;      THIS ROUTINE ACCESSES THE TIME MEMORY
                  9 ;      LOCATIONS AND DISPLAYS THEM IN THE FOLLOWING
                 10 ;      FORMAT:
                 11 ;
                 12 ;      DIG 1   DIG 2   DIG 3   DIG 4
                 13 ;      -----   -----   -----   -----
                 14 ;       HR      HR      MIN     MIN
                 15 ;
                 16 ;      REGISTERS:      A,D,E,H,L
                 17 ;      MEMORY: TIME (2 BYTES)
                 18 ;      STACK SPACE:    2BYTES
                 19 ;      INPUT PORTS:    NONE
                 20 ;      OUTPUT PORTS:   PORTS 2, 3
                 21 ;      PROGRAMMER:     M MANTZ
                 22 ;**************
                 23        CSEG
                 24 TMDSP:
0000 2AB23C      25        LHLD   TIME    ;LOAD H WITH HR, L WITH MIN
0003 EB          26        XCHG           ;PUT IN DE
0004 C30000   E  27        JMP    DISPL   ;DISPLAY IT
                 28 ;
                 29        END
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

                    1        NAME   DTDSP
                    2        PUBLIC DTDSP
                    3        EXTRN  DISPL
3C84                4        DATE   EQU    3C84H
                    5 ;**********
                    6 ;      DISPLAY DATE
                    7 ;
                    8 ;      THIS ROUTINE ACCESSES THE JULIAN DATE MEMORY
                    9 ;      LOCATIONS AND DISPLAYS THEM IN THE FOLLOWING
                   10 ;      FORMAT:
                   11 ;
                   12 ;      DIG 1  DIG 2  DIG 3  DIG 4
                   13 ;      -----  -----  -----  -----
                   14 ;      LS YR  DATE   DATE   DATE
                   15 ;
                   16 ;      REGISTERS:      A,D,E,H,L,
                   17 ;      MEMORY: DATE (2 BYTES)
                   18 ;      STACK SPACE:    2 BYTES
                   19 ;      INPUT PORTS:    NONE
                   20 ;      OUTPUT PORTS:   PORTS 2, 3
                   21 ;      PROGRAMMER:     STAPLETON
                   22 ;**********
                   23        CSEG
                   24 DTDSP:
0000 2A843C        25        LHLD   DATE    ;LOAD H&L WITH DATE
0003 EB            26        XCHG           ;PUT IN DE
0004 C30000    E   27        JMP    DISPL   ;DISPLAY IT
                   28 ;
                   29        END
```

```
                        47 ;
                        48 OUTIT:
0821 2F                 49          CMA             ;INVERT DATA TO PORT
0822 D3E6               50          OUT     PORT3   ;OUTPUT IT AND LATCH PORT
                        51 ;STROBE ALL LATCHES HIGH
0824 DBE5               52          IN      PORT2   ;GET COPY OF LOAD PORT
0826 EEFF               53          XRI     0FFH    ;INVERT UPPER 4 BITS
0828 F60F               54          ORI     0FH     ;SET LOWER 4 HIGH
082A 2F                 55          CMA             ;INVERT FOR OUT
082B D3E5               56          OUT     PORT2   ;HAVEN'T CHANGED UPPER 4 BITS
                        57 ;STROBE SELECTED DIGIT LOW TO LOAD
082D E6F0               58          ANI     0F0H    ;ZERO LOWER 4 BITS
082F B0                 59          ORA     B       ;MERGE INVERTED SELECT BITS.
0830 D3E5               60          OUT     PORT2   ;SEND LOAD CODE
                        61 ;STROBE ALL LATCHES HIGH
0832 E6F0               62          ANI     0F0H    ;RESET LATCHES
0834 D3E5               63          OUT     PORT2   ;REESTABLISH HOLD STATE
0836 C9                 64          RET
                        65 ;
                        66          END
```

```
LOC  OBJ          SEQ          SOURCE STATEMENT

                    1          NAME   DISPL
                    2          PUBLIC DISPL
0001                3 DIG1     EQU    01H     ;DIGIT 1 ENABLE
0002                4 DIG2     EQU    02H     ;DIGIT 2 ENABLE
0004                5 DIG3     EQU    04H     ;DIGIT 3 ENABLE
0008                6 DIG4     EQU    08H     ;DIGIT 4 ENABLE
00E5                7 PORT2    EQU    0E5H    ;PORT 2 8255 #1
00E6                8 PORT3    EQU    0E6H    ;PORT 3 8255 #1
                    9 ;*****************
                   10 ;        DISPLAY ROUTINE
                   11 ;
                   12 ;        DISPLAYS CONTENTS OF D&E REGISTERS ALWAYS.
                   13 ;        'B' REGISTER CONTAINS DIGIT ENABLE. A '1' IN ANY
                   14 ;        OF THE BITS WILL SELECT THAT DIGIT. THIS PROGRAM
                   15 ;        DOES NOT EFFECT THE HIGH ORDER BYTE OF PORT 2.
                   16 ;
                   17 ;        REGISTERS:      A,B,D,E,H,L
                   18 ;        MEMORY: NONE
                   19 ;        STACK SPACE:    2BYTES
                   20 ;        INPUT PORTS:    PORT2,PORT3
                   21 ;        OUTPUT PORTS:   PORT2,PORT3
                   22 ;        PROGRAMMER:     STAPLETON
                   23 ;*****************
                   24          CSEG
                   25 DISPL:
0000 7A            26          MOV     A,D     ;LOAD ACCUM WITH DATA FROM D
0001 0602          27          MVI     B,DIG2
0003 CD2100    C   28          CALL    OUTIT   ;OUTPUT L.O. BYTE
0006 7A            29          MOV     A,D     ;GET ANOTHER COPY
0007 0F            30          RRC
0008 0F            31          RRC
0009 0F            32          RRC
000A 0F            33          RRC             ;MOVE 4 MSB'S TO 4 LSB'S POSITION
000B 0601          34          MVI     B,DIG1
000D CD2100    C   35          CALL    OUTIT
0010 7B            36          MOV     A,E     ;GET DATA FROM E
0011 0608          37          MVI     B,DIG4
0013 CD2100    C   38          CALL    OUTIT
0016 7B            39          MOV     A,E     ;GET ANOTHER COPY
0017 0F            40          RRC
0018 0F            41          RRC
0019 0F            42          RRC
001A 0F            43          RRC
001B 0604          44          MVI     B,DIG3
001D CD2100    C   45          CALL    OUTIT
0020 C9            46          RET
```


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